



FREEPORT-McMoRAN
COPPER & GOLD

Chino Mines Company
Grant County, New Mexico

Administrative Order on Consent
Feasibility Study Proposal
Smelter/Tailings Soils Investigation Unit



Chino Mines Company
99 Santa Rita Mine Road
Vanadium, NM 88023

 **ARCADIS**
Infrastructure, environment, buildings

1687 Cole Boulevard, Suite 200
Lakewood, CO 80401
(303) 231 9115

August 10, 2011

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FREEPORT-MCMORAN CHINO MINES COMPANY – AUGUST 2011

TABLE OF CONTENTS



TABLE OF CONTENTS

| | |
|---|------------|
| TABLE OF CONTENTS | i |
| 1.0 INTRODUCTION | 1-4 |
| 1.1 Background..... | 1-4 |
| 1.2 Objectives | 1-5 |
| 1.3 Summary of Related Current Investigations..... | 1-6 |
| 1.4 AOC Requirements..... | 1-12 |
| 1.5 Organization of FS Proposal..... | 1-13 |
| 2.0 REGULATORY COMPONENTS OF THE FS..... | 2-1 |
| 2.1 AOC FS Tasks | 2-1 |
| 2.2 ARARs..... | 2-4 |
| 2.3 Remedial Action Objectives (RAOs) | 2-6 |
| 2.4 Pre-FS RAC | 2-8 |
| 2.5 AOC Study Boundaries | 2-10 |
| 3.0 DESCRIPTION OF CURRENT SITUATION: SOIL | 3-1 |
| 3.1 Conceptual Site Model | 3-1 |
| 3.1.1 Previous Investigations..... | 3-3 |
| 3.1.2 Nature and Extent of Contamination | 3-5 |
| 3.2 Exposure Units | 3-7 |
| 3.3 Data Needs..... | 3-8 |
| 4.0 DESCRIPTION OF CURRENT SITUATION: SURFACE WATER..... | 4-1 |
| 4.1 Conceptual Site Model | 4-1 |
| 4.1.1 Previous Investigations..... | 4-4 |
| 4.1.2 Nature and Extent of Contamination | 4-5 |
| 4.2 Data Needs..... | 4-6 |
| 5.0 REMEDIAL TECHNOLOGIES: SOIL..... | 5-1 |
| 5.1 No Action | 5-2 |
| 5.2 Monitoring..... | 5-3 |
| 5.3 Excavation and Reuse..... | 5-4 |
| 5.4 Excavation and Disposal..... | 5-6 |
| 5.5 Soil Amendments – Limestone and Organic Matter | 5-7 |
| 5.6 Soil Amendments - Tilling | 5-10 |
| 5.7 Soil Amendments – Ferrihydrite | 5-11 |
| 5.8 Soil Amendments – Chelating Agents..... | 5-12 |
| 5.8.1 Soil Washing (Ex-Situ)..... | 5-13 |

| | | |
|------------|---|-------------------------------------|
| 5.8.2 | Soil Washing (In-Situ)..... | 5-14 |
| 5.8.3 | Phytoextraction..... | 5-15 |
| 5.9 | Containment – Soil Cover | 5-17 |
| 5.10 | Containment – Impermeable Cover..... | 5-18 |
| 5.11 | Surface Soil Controls – Phytostabilization | 5-19 |
| 5.12 | Phytoremediation..... | 5-20 |
| 5.13 | Electrokinetic Remediation | 5-22 |
| 5.14 | Summary and Identification of Data Needs..... | 5-23 |
| 6.0 | REMEDIAL TECHNOLOGIES: SURFACE WATER | 6-1 |
| 6.1 | No Action | 6-1 |
| 6.2 | Monitoring..... | 6-2 |
| 6.3 | Excavation | 6-3 |
| 6.4 | In Stream Removal of Suspended Sediments | 6-5 |
| 6.5 | Limestone Treatment..... | 6-6 |
| 6.6 | Alkaline Washing | Error! Bookmark not defined. |
| 6.7 | Sediment and Erosion Control..... | 6-9 |
| 6.8 | Summary and Identification of Data Needs..... | 6-10 |
| 7.0 | SCHEDULE..... | 7-1 |
| 8.0 | REFERENCES..... | 8-1 |

TABLES

| | |
|-----|--|
| 2-1 | Chemical-Specific Potentially Applicable Standards for the STSIU |
| 2-2 | Action-Specific Potentially Applicable Standards for the STSIU |
| 2-3 | Location-Specific Potentially Applicable Standards for the STSIU |
| 3-1 | Summary of Surface Soil Arsenic and Iron Results |
| 3-2 | Surface Soil Copper Results Adjusted to 0 – 6 inches |
| 3-3 | STSIU Soil pCu Values |
| 4-1 | Surface Water Hazard Quotients (HQs) for Dissolved Cadmium |
| 4-2 | Surface Water HQs for Dissolved Copper |
| 4-3 | Surface Water HQs for Dissolved Lead |
| 5-1 | Preliminary Screening of Remedial Technologies for Soil |
| 6-1 | Preliminary Screening of Remedial Technologies for Surface Water |

FIGURES

- 1-1 Site Overview
- 2-1 AOC Boundary and Investigation Units
- 3-1 Conceptual Site Model
- 3-2 Copper Contours Estimated from Soil (0 – 6 inches)
- 3-3 Iron Contours Estimated from Soil (0 – 1 inches)
- 3-4 pCu Contours Estimated from Soil (0 – 6 inches)
- 4-1 Surface Water Hydrology and Stock Tank Locations
- 4-2 Surface Water Sample Locations with Cadmium HQ Values > 1
- 4-3 Surface Water Sample Locations with Copper HQ Values > 1
- 5-1 Amendment Study Plot Locations
- 7-1 FS Schedule

Appendices

- A Upland Soil Field Sampling Plan
- B Surface Water Field Sampling Plan

GLOSSARY

| | |
|--------|---|
| ABA | Acid base accounting |
| AOC | Administrative Order on Consent |
| ARAR | Applicable or Relevant and Appropriate Requirements |
| BAF | Bioaccumulation Factor |
| bgs | Below Ground Surface |
| BLM | Biotic Ligand Model |
| BMP | Best Management Practices |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CGCS | Comprehensive Groundwater Characterization Study |
| Chino | Freeport-McMoRan Chino Mines Company |
| COC | Constituent of Concern |
| COPC | Constituent of Potential Concern |
| CSM | Conceptual Site Model |
| CY | Cubic Yards |
| DOT | Department of Transportation |
| DP | Discharge Permit |
| ERA | Ecological Risk Assessment |
| FS | Feasibility Study |
| FSP | Field Sampling Plan |
| FRMS | Freeport-McMoRan Reclamation Services |
| HHRA | Human Health Risk Assessment |
| HSIU | Hurley Soils Investigation Unit |
| HWCIU | Hanover/Whitewater Creeks Investigation Unit |
| IA | Investigation Area |

| | |
|--------|--|
| IRA | Interim Remedial Action |
| IU | Investigation Unit |
| LDR | Land Disposal Regulation |
| MS/MSD | Matrix Spike/Matrix Spike Duplicate |
| NCP | National Contingency Plan |
| NDVI | Normalized Difference Vegetation Index |
| NMAC | New Mexico Administrative Code |
| NMED | New Mexico Environmental Department |
| NMWQA | New Mexico Water Quality Act |
| OAT | Observed Apparent Trend |
| OMM | Operation, Maintenance and Monitoring |
| OPCZ | Open Pit Capture Zone |
| pCu | Cupric ion activity (pCu^{2+}) |
| pH | Hydrogen ion (standard units) |
| RAC | Remedial Action Criteria |
| RAOs | Remedial Action Objectives |
| RCRA | Resource Conservation Recovery Act |
| RI | Remedial Investigation |
| ROW | Right of Way |
| SGFB | Small ground feeding bird |
| SPLP | Synthetic Precipitation Leaching Procedure |
| SSL | Soil Screening Level |
| STSIU | Smelter/Tailing Soils IU |
| TBC | Top Be Considered |
| TOC | Total organic carbon |
| UAA | Use Attainability Analysis |
| UCL | Upper Confidence Limit |

USPEA United States Environmental Protection Agency

WER Water Effect Ratio

WQCC Water Quality Control Commission

WQS Water Quality Standard

EXECUTIVE SUMMARY

The objective of the Feasibility Study (FS) Proposal for the Smelter/Tailing Soils Investigation Unit (STSIU) is to present activities necessary to evaluate remedial alternatives that comply with New Mexico Environment Department (NMED) Pre-FS remedial action criteria (RAC). The data generated through implementation of the FS Proposal will be used to evaluate potential remedial alternatives, and the data and evaluations will be reported in FS Report.

In accordance with the AOC Scope of Work, a Remedial Investigation (RI) for the STSIU was conducted to generate the data necessary to evaluate the potential effects to human health and the environment from historically affected media in the STSIU. Data have been collected in the STSIU starting in 1995 and continuing through 2010 to determine potential impacts to soil, sediment, and surface water from historical mineral processing activities. NMED issued Pre-FS RAC for the STSIU of 27 mg/kg arsenic in soil (0-1"), 5,000 mg/kg copper in soil (0-1"), 1,600 mg/kg copper in soil (0-6"), 100,000 mg/kg iron in soil (0-1"), and cupric ion activity (pCu^{2+}) (hereafter referred to as "pCu") ≥ 5 where copper > 327 mg/kg (NMED, 2010, 2011). Surface water Pre-FS RAC were based upon New Mexico Administrative Code (NMAC) §20.6.4. These Pre-FS RAC values were developed based on the evaluations conducted in the RI, HHRA, and ERA. The FS and Record of Decision (ROD) will be completed consistent with the National Contingency Plan (NCP). Pre-FS RAC are consistent with the use of preliminary remediation goals (PRG) by EPA in the NCP; therefore, new information can be used to refine the Pre-FS RAC and selection of alternatives (§300.430(e)(2)(i) NCP). Final remediation goals will be determined in the Record of Decision.

Surface Soil

Soils within the STSIU were affected by stack and fugitive dust emissions from historical mineral processing and beneficiation activities associated with the former Hurley Operations Area and the tailings area. The AOC Background Report (Chino, 1995) identified the primary sources of contamination in the former Hurley Operations Area resulting from historical smelting, milling, concentrating, and handling of copper ore. For the tailings area of the STSIU, the tailings impoundments are considered the primary source of constituents of interest that have the potential to affect environmental media. Both historical and operational tailing may have affected surrounding media; however, DP-214, DP-484 and DP-1340 address any groundwater impacts from the historical or current facilities due to infiltration to groundwater, and that will not be addressed in the FS.

Based upon a review of the available data and the Pre-FS RAC, additional sampling is needed to refine the potential remedial areas for all constituents that exceed their respective criteria. The exact sampling locations and methods are presented in the Upland Sampling Work Plan (Appendix A). The Upland Sampling Work Plan (Appendix A) also describes the methodology that will be used to perform rangeland and drainage habitat surveys to better understand the potential habitat units in the STSIU. NMED requires that the copper Pre-FS RAC for birds be applied as a 95 percent upper confidence limit of the spatially weighted average concentration over a habitat unit.

Through remote sensing with field verification, habitat units will be defined for the STSIU and presented in the FS Report.

The following soil remedial technologies were evaluated in the preliminary screen:

- No Action;
- Monitoring;
- Excavation and Reuse;
- Excavation and Disposal;
- Soil Amendments – Lime and/or Organic Matter;
- Soil Amendments - Tilling
- Soil Amendments – Chelating Agents;
- Soil Amendments – Ferrihydrite;
- Containment – Soil Cover;
- Containment – Impermeable Cover;
- Surface Soil Controls – Phytostabilization;
- Phytoremediation; and
- Electrokinetic Remediation.

All of these soil remedial technologies, with the exception of chelating agents as a soil amendment, impermeable soil cover, phytoremediation, and electrokinetic remediation were retained for further evaluation in the FS Report. Besides ongoing sampling activities, there are no additional data needs that need to be considered based on this preliminary screen of remedial alternatives for soil.

Surface Water

Surface waters and drainages in the STSIU include Bolton Draw, Rustler Canyon, Martin Canyon, and other un-named tributaries of Whitewater Creek and Lampbright Draw. These drainages are commonly considered ephemeral, with surface water flow occurring during and immediately after a precipitation event. Other than these drainages, the remaining surface water bodies present in the STSIU are livestock watering tanks and a small number of persistent pools in some of the STSIU drainages. The livestock tanks are generally designed to catch surface water run-off and to hold water for long periods of time after a precipitation event, but some of the livestock tanks also

collect windmill well water and/or spring water in addition to surface run-off. There are more than 20 small to large sized livestock tanks throughout the STSIU.

The NMED Pre-FS RAC for metals in surface waters was based on Part 20.6.4 NMAC, including all the tools and approaches listed in the Code which provide for site-specific application. All of the surface waters and drainages listed above are “unclassified” waters under current Part 20.6.4 NMAC. Unclassified surface waters are treated as perennial or intermittent waters unless a use attainability analysis (UAA) is performed and accepted as showing that the waters should be treated as “ephemeral.” Based on a preliminary evaluation conducted in 2010, it is expected that the vast majority of these drainages may fit the characteristics of ephemeral waters. The Statewide Water Quality Management Plan and Continuing Planning Process (WQCC, 2011) provides a decision tree for expedited UAA Process for unclassified ephemeral streams (see Figure II-2 in WQCC, 2011). A work plan to determine hydrologic regime for tributary channels within the STSIU sub-watersheds was submitted to the Surface Water Quality Bureau and implemented in June 2011. The objectives of the hydrology work plan include (1) conducted expedited UAA for STSIU drainages based on application of New Mexico’s Hydrology Protocol and (2) conduct a separate UAA for stock tanks within STSIU. The results of this work will be incorporated into the FS report.

For most metals, criteria are expressed as a function of site-specific water hardness; however, these hardness-adjusted criteria do not account for other key chemical parameters that potentially alter metal bioavailability and toxicity. As such, other options are available to derive site-specific water quality criteria. Section 131.11 (b) (ii) of the federal water quality standards regulation (40 CFR Part 131) provides the regulatory mechanism for a State to develop site-specific criteria for use in water quality standards. Further, as a result of New Mexico’s Triennial Review of surface water standards, new provisions are available for establishing segment-specific surface water criteria. As specified in §20.6.4.10.D NMAC, site-specific criteria may be developed when physical or chemical characteristics at a site alter the bioavailability or toxicity of a chemical. Site-specific criteria may be derived from one of the following procedures: water effect ratio (WER), biotic ligand model (BLM), recalculation procedure, or the resident species procedure.

Based on these Triennial revisions and a preliminary review of Chino’s surface water chemistry, WER and/or BLM procedures are appropriate for deriving site-specific metal criteria for surface waters at Chino. A criteria-adjustment work plan was submitted to the Surface Water Quality Bureau concurrent with this STSIU FS Proposal and findings may result in a rulemaking petition. The work plan describes studies that will be used to understand the site-specific toxicity of copper in STSIU surface waters. These studies are based on scientifically-defensible methods described in §20.6.4.10 NMAC, and are designed to incorporate the effects of site-specific water chemistries on the bioavailability and toxicity of copper to aquatic organisms. It is further envisioned that results from these criteria-adjustment studies will provide the data necessary for the establishment of site-specific copper criteria.

In addition to these studies, Appendix B provides a separate work plan for further understanding the conceptual site model of STSIU drainages and stock tanks. This work plan includes the use of stormwater samplers that sample run-off and the data will be used to allocate metals load in surface water to upgradient sources, soil sources or legacy sediment sources.

The following surface water remedial technologies were evaluated in the preliminary screen:

- No Action;
- Monitoring;
- Excavation;
- In-stream Removal of Suspended Sediments;
- Limestone Treatment;
- In-situ Treatment; and
- Sediment and Erosion Control.

All of these surface water remedial technologies were retained except for in-situ treatment for further evaluation in the FS Report. Besides ongoing sampling activities, there are no additional data needs that need to be considered based on this preliminary screen of remedial alternatives for surface water.

1.0 INTRODUCTION

The Feasibility Study (FS) Proposal was prepared for Freeport-McMoRan Chino Mines Company (Chino) to develop and evaluate potential remedial alternatives for the Smelter Tailings Soil Investigation Unit (STSIU) at the Chino Mine Investigation Area, Grant County, New Mexico (site). This FS Proposal has been developed in accordance with the requirements in the Administrative Order on Consent (AOC) following the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) guidance. The AOC, effective December 24, 1994, distinguishes between historical mineral processing activities and current operations at Chino.

1.1 Background

The STSIU is one of the Investigation Units identified within the Investigation Area (IA) of the AOC. The IA includes all areas in which environmental media may have been affected by historical operations at mining and processing facilities. The STSIU is located approximately 12 miles southeast of Silver City, and includes historical smelting facilities, mineral processing facilities tailing impoundments, and surrounding areas (Figure 1-1). The STSIU is located to the

east of the town of Hurley, New Mexico which contained the Hurley Smelter, and has previously been defined as all areas containing and proximal to Chino's former copper smelter and ancillary facilities, including the tailings disposal facility (SRK, 2008a).

In accordance with the AOC Scope of Work, a Remedial Investigation (RI) for the STSIU was conducted to generate the data necessary to evaluate the potential effects to human health and the environment from historically effected media in the STSIU. Data have been collected in the STSIU starting in 1995 and continuing through 2010 to determine potential impacts to soil, sediment, and surface water from historical mineral processing activities. The human health risk assessment (HHRA) and ecological risk assessment (ERA) have shown that areas of the STSIU have elevated metals concentrations and depressed pH in soil and surface water, as described in Section 3.1.1 and 4.1.1.

NMED issued the pre-Feasibility Study Remedial Action Criteria (Pre-FS RAC) for the STSIU of 27 mg/kg arsenic in soil (0-1"), 5,000 mg/kg copper in soil (0-1"), 1,600 mg/kg copper in soil (0-6"), 100,000 mg/kg iron in soil (0-1"), and cupric ion activity (pCu^{2+}) (hereafter referred to as "pCu") ≥ 5 where copper > 327 mg/kg (NMED, 2010, 2011). Surface water Pre-FS RAC were based upon New Mexico Administrative Code (NMAC) §20.6.4. These Pre-FS RAC values were developed based on the evaluations conducted in the RI, HHRA, and ERA. The FS and Record of Decision (ROD) will be completed consistent with the National Contingency Plan (NCP). Pre-FS RAC are consistent with the use of preliminary remediation goals (PRG) by EPA in the NCP; therefore, new information can be used to refine the Pre-FS RAC and selection of alternatives (§300.430(e)(2)(i) NCP). Final remediation goals will be determined in the Record of Decision. Further details about the Pre-FS RAC are presented in Section 2.4.

1.2 Objectives

The primary objectives of this FS Proposal are to identify potential remedial areas and remedial technologies to address contaminated soil, sediment, and surface water in the STSIU. To achieve this, remedial action objectives (RAOs) were developed to define the basis for remediation, including numerical Pre-FS RAC as discussed in the previous section. Remedial technologies described in this document were assessed using the CERCLA FS criteria (Section 4.3, USEPA, 1988) to determine their potential to meet the project RAOs.

Remedial technology alternatives evaluated in this report are analysed individually and in comparison with each other using the following criteria: overall protection of human and ecological receptors, compliance with applicable or relevant and appropriate requirements (ARARs); long-term effectiveness and permanence; reduction in toxicity, implementability; and cost. The FS Proposal process used in this document generally consists of the following:

- Summarize RAOs and Pre-FS RAC that address the key risk drivers and potential routes of exposure;

- Identify areas where potential remedial action would apply;
- Identify and screen potential remedial technologies;
- Identify data gaps that would aid in the determination of either remedial areas or selection of remedial technologies;
- Develop and produce Work Plans deemed necessary to further delineate contamination or to determine the most effective remedial technologies prior to the production of the FS.

The above steps will be used to guide the development of potential sampling events and pilot studies that will be conducted prior to determining the most appropriate remedial alternative in the FS.

1.3 Summary of Related Current Investigations

Between the start of the AOC process in April 1995 and December 2010, there are a number of site characterization or remediation activities in or near the STSIU at Chino. These include the following:

- Phase 1 Remedial Investigation Proposal, Hurley Soils Investigation Unit, Rev 2.0 (Golder, 1998);
- Phase 1 Remedial Investigation Proposal, Hanover and Whitewater Creeks Investigation Unit (Golder, 1999a)
- Comprehensive Groundwater Characterization Study (CGCS) (Golder 1999b)
- Phase II Revised Remedial Investigation Report, Hurley Soils Investigation Unit (Golder, 2000a)
- Phase 1 Revised Remedial Investigation Report, Hanover/Whitewater Creek Investigation Unit (Golder, 2000b)
- Lake One Reclamation FS (Golder, 2007a)
- Slag Pile Characterization (Golder 2007b)
- Interim Removal Action for STSIU (ARCADIS, 2006a, 2009)
- STSIU Terrestrial Invertebrate Bioaccumulation and Bioavailability Study (ARCADIS, 2010a)
- STSIU Amendment Study (ARCADIS, 2008a, 2010b & 2011a)

- STSIU pH Monitoring (ARCADIS, 2011b)
- Groundwater Quality Pre-FS RAC for Drainage Sediments Study (ARCADIS, 2011c)

A brief overview of some of these reports or site characterization activities is provided below.

Hurley Soils IU RI

The RAO for the HSIU was to prevent incidental ingestion of soil containing copper concentrations that exceed 5,000 mg/kg. The remedial action selected for the Hurley Interim Remedial Action (IRA) was soil excavation with restoration using clean fill and landscaping materials in those properties where soil copper concentrations were greater than the NMED-issued pre FS-RAC of 5,000 mg/kg copper. Preliminary remediation activities began in the summer of 2005 with a pilot program, preliminary request for access to properties, and soil sampling. The Hurley IRA was conducted per the NMED-approved work plan (Golder, 2006) between June 2005 and August 2007.

Remediation was required in areas where analysis of surface soil samples indicated copper concentrations were greater than the RAC based on the Round 1 sampling results. During the course of the Hurley IRA, 629 residential sites, 44 non-residential sites, and 74 alleys and easement areas were sampled for elevated concentration of copper. A total of 29,327 soil samples were collected and analysed as part of the process. As a result of these analyses, 486 residential properties, 37 non-residential properties, and 60 alleys and easement areas were determined to require remediation.

As a result of remediation activities, 40,948 cubic yards of soil containing elevated concentrations of copper were excavated and transported to Lake One where the soil was staged temporarily prior to hauling it to the mine stockpiles for blending and placement on leach stockpiles for recycle.

In locations where excavation occurred, confirmation samples were collected from the remaining surface soil in the same areas as the initial round of sampling to determine whether the Pre-FS RAC was achieved. After the Pre-FS RAC was achieved, the properties were restored with clean fill and landscaping materials.

Hanover/Whitewater Creek IU RI

The RI proposal for the Hanover/Whitewater Creek IU (HWCIU) was completed in May 1999 (Golder, 1999a), and following the field sampling event, the RI Report was completed in May, 2000 (Golder, 2000b). This IU includes the primary channels and major tributaries of Hanover Creek and Whitewater Creek. Whitewater Creek flows southward along the east boundary of the Hurley/tailing operational area.

The objectives of the RI were to evaluate initial assumptions about the physical system, update the site conceptual model based on that evaluation, and to characterize media within the physical

system as a basis for the NMED to derive representative exposure point concentrations. The RI included sampling of creek sediments, surface water, and surface soil from the channel overbanks. In 2007, additional sediment, seed, foliage and invertebrate data was collected to fulfill ecological data needs for the HWCUI specific ERA. Since that time, NMED issued a draft final HHRA report (Neptune, 2007) and a draft ERA (Newfields, 2008a).

Comprehensive Groundwater Characterization Study

The three-phase Comprehensive Ground Water Characterization Study (CGCS), which began in 1997 and was completed in 1999, presents a comprehensive, site wide evaluation of ground water characteristics, including:

- A compilation of all existing hydrogeologic and geochemical data; and
- A conceptual model of the ground water systems in various areas of the mine.

Condition 83 of DP-1340 required Chino to update the 1999 CGCS. The objectives of the Chino Mines Company DP-1340 Condition 83 – Hydrologic Study (Condition 83 – Hydrologic Study), which was submitted to NMED in 2007, included:

- Evaluating the hydrologic conditions beneath the tailing ponds in the SouthMine Area, and waste rock and leach stockpiles in the North Mine Area;
- Updating the original CGCS;
- Updating the boundaries for the Open Pit Capture Zone (OPCZ) that were presented in the original CGCS; and
- Determining whether the regulatory requirements of the NM Water Quality Act (WQA) and the NM Water Quality Control Commission (WQCC) will be met with the proposed closure activities.

Another objective of the Condition 83 – Hydrologic Study was to collect data that can be used to assist with abatement activities and closure. The work undertaken for this study was directly tied to work being undertaken as part of Chino's on-going investigation in support of its Site Wide Abatement Plan. The WQCC abatement regulations establish a two stage abatement plan process. The objectives of Stage 1 are to define site conditions and provide the necessary data for selecting and designing an abatement plan. The current phase of the Stage 1 scope at Chino includes evaluating ground water in the area where Whitewater Creek discharges to Lake One. This additional field data was used to update the models developed as part of Condition 83, and used to evaluate abatement strategies and, eventually, various closure scenarios under DP-1340.

Lake One Closure FS

Chino performed a feasibility study for Lake One in accordance with Condition 90 of the Supplemental Discharge Permit, DP-1340. The primary objective of the Lake One FS was to provide the basis for the selection of a closure alternative. Chino submitted the Lake One Closure FS (Golder, 2007a) to the NMED on October 5, 2007, which identified the following preferred option:

- Regrading and covering the materials in Lake One following conclusion of the removal of sediment for copper recovery;
- Establishing a "no-flow" barrier to intercept alluvial subsurface flow in Whitewater Creek upstream of Lake One;
- Treatment of extracted groundwater with lime at the Hurley Water Treatment Plant prior to commingling and discharge; and
- Continuing extraction of ground water down gradient from Lake One using the current interceptor system below Tailing Pond 7.

Chino has completed removal of copper bearing sediments from Lake One for placement and recycle on active leach stockpiles in the mine area. Closure of Lake One currently is scheduled to be implemented in 2013 after Chino submits and NMED approves the Lake One Closure Plan.

Slag Pile Characterization

The *Chino Slag Pile Characterization Study Report and Closure Plan* (Golder, 2007b) was submitted August 29, 2007 to NMED, per Permit Condition 89 of DP-1340. The study presents analytical data and proposes a closure plan for the slag area that meets the requirements of both the Water Quality Act and the Water Quality Control Commission Regulations.

Interim Removal Action for STSIU

The *Interim Removal Action (IRA) for the STSIU* (ARCADIS, 2006, 2009) addressed elevated copper in surface soil to the north and west of Hurley, New Mexico. A former golf course existed to the north of the Town of Hurley. The North and South Golf Course designation refers to this area; the division between the north and south is the access road to the Chino facility entrance in Hurley.

The objective of the IRA was to remove areas where soil copper concentrations were greater than 5,000 milligrams per kilogram (mg/kg) (lateral delineation). Chino applied the NMED-approved residential RAC for the HSIU as a conservative measure. Within the area exceeding 5,000 mg/kg copper, the excavation was completed vertically until the soil did not exceed 2,700 mg/kg copper.

Freeport-McMoRan Reclamation Services (FMRS) performed the IRA excavation activities in partnership with ARCADIS, who conducted the field engineering services, which took place from January 10, 2008 to August 12, 2008. Excavation depths during the IRA activities averaged three inches bgs for the total removal area. Based on confirmation sampling and refinement of the removal areas, approximately 170 acres of the proposed 190 acres were ultimately remediated. Final excavation volumes were determined by contractor load counts. The total volume removed during this IRA is estimated at 68,112 cubic yards (CY).

STSIU Terrestrial Invertebrate Bioaccumulation and Bioavailability Study

The *Terrestrial Invertebrate Copper Bioaccumulation and Bioavailability Study for STSIU* describes the September 2010 terrestrial invertebrate and soil sampling in the STSIU to support the development of an updated soil-to-invertebrate bioaccumulation factor (BAF) for copper and to determine the relative bioavailability of insect tissue copper concentrations (ARCADIS, 2010a). Chino believed the BAF calculated from the 1999 ERA samples was biased high based on the following technical uncertainties:

- Using unwashed insect tissue;
- Using wet weight tissue concentrations;
- The STSIU soil copper and pH changes resulting from the 2008 “white-rain” event;
- The potential for copper concentrations to be naturally attenuating since the demolition of the smelter stacks in 2007.

The 2010 results showed a decrease in overall copper uptake by terrestrial invertebrates. This decrease in uptake was noted for insects collected in areas with soil copper concentrations ranging from less than 200 mg/kg to above 2,000 mg/kg. The 2010 results were used to refine the BAF for copper uptake by insects and determine a copper bioavailability value in insect tissue. The revised invertebrate BAF and copper bioavailability value were incorporated into the dose model when revising the avian Pre-FS RAC for the STSIU.

STSIU Amendment Study Plots

Chino implemented the STSIU Amendment Study in 2008 based upon an NMED-approved work plan to explore the possible remedial options to determine if lime and organic matter amendments with or without tilling could be an effective and feasible remedial action to address the elevated copper concentrations and depressed pH in surface soils within the STSIU (ARCADIS, 2008a). The study is testing longevity of pH stabilization, copper sequestration ability, vegetative recolonization, and constructability.

In June of 2008, Chino applied lime and organic matter to three test plots, and one test plot was used as a control with no amendments or tilling. During the application of lime and organic matter,

two of the test plots were also tilled. Chino conducted monitoring of the copper, pH, and vegetation cover before and after amendment application. The results from the monitoring events were presented in the first two annual reports and have been submitted to NMED (ARCADIS 2010b and 2011a). The amendment monitoring will continue through 2013 when the effectiveness of the amendments will be determined.

STSIU pH Monitoring

A significant shift in pH upward was observed in the STSIU following a "white rain" precipitation event on January 7, 2008 (ARCADIS, 2008b). To quantify the permanence of this trend, Chino submitted, and NMED approved, the Soil pH Monitoring Work Plan in 2010 (ARCADIS, 2010c). The Work Plan outlined eighteen locations (increased to 22 in 2011) to monitor soil pH over 5 years, with annual reports provided to NMED after each sampling event summarizing the results.

The AOC Year 1 pH Monitoring Report was focused on evaluating if the pH and pCu increases in upland soils that resulted from the "white rain" event are temporary or permanent. During the "white rain" event a milky alkaline rain containing calcium was deposited on the mine site. The pH levels in rain water at a weather station located 40 miles north of Chino at Gila Cliffs Dwellings National Monument were higher than had been observed in 21 years and, additionally, the high calcium levels recorded at the Monument had not been observed at these levels for 15 years. The white rain appeared to effectively neutralize most of the acidic Chino soils with calcium carbonate. The first annual report on the pH monitoring has been provided to NMED (ARCADIS 2011b). The pH monitoring will continue through 2013 when the permanence of the white rain effects will be determined.

Groundwater Pre-FS RAC for Drainage Sediments Study

NMED provided Chino with a Pre-FS RAC letter on September 16, 2010 which requested further evaluation of groundwater pathways in the STSIU. To acquire the requested information, Chino provided NMED with the *Sediment Leaching to Groundwater Evaluation Work Plan* on October 20, 2010, which was approved by NMED on November 8, 2010. The field efforts that were proposed in the Work Plan commenced in early December 2010 as a joint effort between Chino, ARCADIS, and NMED.

The *Groundwater Quality Pre-FS RAC for Drainage Sediments Report* (ARCADIS, 2011c) describes the December 2010 sediment sampling activities in the STSIU and the associated data analysis that was used to assess potential impacts to groundwater quality resulting from the sediment leaching to groundwater pathway.

The study found that iron was the only constituent with synthetic precipitation leaching procedure (SPLP) concentration exceeding its respective New Mexico Groundwater Standards; therefore, it was the only constituent for which site-specific soil screening levels (SSLs) were developed using Kd values derived from the SPLP results. Chino chose the most conservative iron Kd value from

sample BD-1 Drainage (0-0.5 feet) of 8,813 L/kg to use when calculating the site-specific SSL. Using the conservative Kd and the New Mexico Tap Water Standard of 25.6 mg/L, the resulting SSL for iron is 225,621 mg/kg, which is greater than any sampled sediment iron concentration in the STSIU. The high site-specific SSL value is supported by the Gradient (2008) STSIU HHRA results where there were no exceedances of groundwater criteria for iron.

1.4 AOC Requirements

The AOC between Chino and NMED became effective on December 24, 1994 and requires Chino to conduct the following work:

- Assess present STSIU condition in the investigation area associated with risks to public health and welfare of the environment;
- To the extent necessary to select a remedy, or remedies, evaluate alternative remedial technologies appropriate for the IU in the investigation area; and
- Implement the selected remedy or remedies.

Anticipated FS activities that were identified in the AOC Scope of Work include, but are not limited to:

- Description of current situation;
- Treatability studies and identification and screening of potential applicable technologies;
- Development of remedial alternatives;
- Initial screening of remedial alternatives;
- Detailed evaluation of remedial alternatives;
- Description and justification of preferred alternative;
- Production of the FS report.

This FS Proposal addresses the first two items in this list.

1.5 Organization of FS Proposal

This FS Proposal was prepared to determine and fulfil the needed data requirements of the AOC identified FS activities. The FS Proposal is organized as follows:

Section 1.0: Introduction

Section 2.0: Regulatory Components of the FS

Section 3.0: Description of Current Situation: Soil

Section 4.0: Description of Current Situation: Surface Water

Section 5.0: Remedial Technologies: Soil

Section 6.0: Remedial Technologies: Surface Water

Section 7.0: Implementation of Schedule

2.0 REGULATORY COMPONENTS OF THE FS

There are a number of regulatory components associated with an FS that need to be presented in this FS proposal. Section 2.1 presents the specific FS tasks that are stated and required in the AOC associated with STSIU. Section 2.2 presents the ARARs associated with the STSIU. Sections 2.3 and 2.4 provide details on the RAOs and the Pre-FS RAC that have been developed for the STSIU. Finally, Section 2.5 describes the AOC STSIU study boundaries.

2.1 AOC FS Tasks

The following FS tasks, as stated and required in the AOC in Appendix A, will be completed during the overall FS process (NMED, 1994):

Description of Current Situation

Chino shall develop a summary of the current understanding of the STSIU, based on historical information as well as information obtained during the RI. This summary will include information concerning Waste Material characteristics, exposure routes, human and environmental targets, risk posed by Waste Materials on the IU, and, if applicable, off-Investigation Unit risks posed by the migration of Waste Materials from the IU

The summary shall state the purpose of the FS and will include identifications of exposure pathways which should be addressed during assessment of remedial alternatives. Remedial response objectives will be developed based on the current understanding of the IU, the HHRA and ERA, and a proposed final list of RAC.

Treatability Studies and Identification and Screening of Potentially Applicable Technologies

Chino shall identify treatment technologies potentially appropriate for remediation of Waste Material originating from or occurring at the IU through literature review and bench or pilot studies. If necessary, Chino shall design treatability studies for the most promising treatment technologies identified. Prior to initiation of any treatability studies, Chino shall develop and submit for NMED approval a Treatability Study Work Plan identifying the types and goals of the studies, a schedule for completion, and a data management plan.

A master list of potentially feasible technologies will be developed based on IU specific problems and general response objectives identified. These technologies may include both on-IU and off-IU remedies, depending on the problems identified. The list of technologies will be screened based on IU conditions, contaminate characteristics, and technologies development to eliminate or modify those technologies that may prove extremely difficult to implement, will require unreasonable time periods, or will rely on insufficiently developed technology.

Development of Remedial Alternatives

Chino shall develop potentially applicable technologies identified in the above section into remedial alternatives. The technologies will address the RAOs, be based on accepted engineering practices and principles, and reduce the toxicity, mobility, and volume of waste material. The rationale for excluding technologies will be documented. Remedial action alternatives will be developed for each of the following categories, consistent with the requirements of CERCLA:

- No action;
- Remedial action which does not attain public health or environmental standards (i.e., RAC) but will reduce the likelihood of a present or future threat from the hazardous substances. This alternative must closely approach the level of protection provided by an applicable standard;
- Attainment of public health or environmental standards (i.e., RAC);
- Remedial action which exceeds public health and environmental standards, and
- Removal for treatment or disposal.

Initial Screening of Remedial Alternatives

Chino may, with prior NMED approval, eliminate from further consideration alternatives which obviously do not meet Health and Environmental Risk Assessment objectives or are not technically feasible for conditions at the IU. Alternatives will be evaluated for:

- Environmental protection and effects;
- Effectiveness and ability to be implemented;
- Technical feasibility; and
- Cost (this factor may be considered only after environmental and public health factors have been considered, and will not be the basis for eliminating any alternatives at this point).

Evaluation of Remedial Alternatives

Chino shall develop in detail, and evaluate for consistency with CERCLA, remedial action alternatives which meet the remedial response objectives. The detailed development will include:

- A description of treatment, storage, and disposal technologies to be used;

- A discussion of how each remedy does (or does not) comply with specific requirements of environmental laws and regulations. When an alternative does not comply, a description of special design considerations which could affect compliance will be included;
- A description of environmental impacts of proposed methods and costs or mitigating any adverse affects;
- An assessment of operation, maintenance, and monitoring requirements of each remedy and their costs;
- A review of any facilities proposed for use to ensure compliance with RAC and to determine if off-IU management of Waste Material could result in the potential for a future release from the disposal or waste-management facility;
- Identification of temporary storage requirements, disposal needs, and transportation plans;
- An assessment of each alternative to determine whether it results in permanent treatment or destruction of the wastes, and if not, the potential for future releases to the environment;
- A description of the safety requirements for implementing each remedial alternative; and
- A description of special engineering requirements or site preparation considerations for each remedial alternative.

Chino shall, consistent with CERCLA, specifically assess the alternatives to determine:

- Overall protection of human health and the environment;
- Compliance with public health and environmental standards;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, and volume through treatment;
- Short-term effectiveness;
- Ability to be implemented;
- Cost-effectiveness (including the present value of costs of implementation and extended remedial action); and
- Community acceptance.

Note: this list is taken directly from the AOC which lists eight criteria, but Section 5 and 6 herein discuss the nine criteria that are cited in the National Contingency Plan.

Description and Justification of Preferred Alternative

In the FS Report, Chino shall describe and justify its preferred alternative based on the criteria listed above.

2.2 ARARs

Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address the situation at a CERCLA site. The requirement is applicable if the jurisdictional prerequisites of the standard show a direct correspondence when objectively compared to conditions at the site. An applicable federal requirement is an ARAR. An applicable state requirement is an ARAR only if it is more stringent than the federal ARAR.

If the requirement is not legally applicable, then the requirement is evaluated to determine whether it is relevant and appropriate. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable, address problems or situations similar to the circumstances of the proposed response action (relevant) and are well suited to the conditions (appropriate) of the site. A requirement must be determined to be both relevant and appropriate in order to be considered an ARAR.

The criteria for determining relevance and appropriateness are listed in the Code of Federal Regulations (40 CFR), Section 300.400(g)(2), and include general comparisons between the following:

- The purpose of the requirement and the purpose of the action;
- The medium regulated or affected by the requirement and the medium contaminated or affected at the site;
- The substances regulated by the requirement and the response action contemplated at the site;
- Any variances, waivers, or exemptions of the requirement and their availability for the circumstances at the site;
- The type of place regulated and the type of place affected by the release; and
- Any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resources at the site.

According to the USEPA CERCLA guidance, a requirement may be “applicable” or “relevant and appropriate” but not both (USEPA, 1988). Identification of ARARs must be done on a site-specific basis and involves a two-part analysis: first, a determination of whether a given requirement is applicable; and then, if it is not applicable, a determination of whether it is, nevertheless, both relevant and appropriate. When the analysis determines that a requirement is not applicable but is both relevant and appropriate, the requirement must be compiled with the same degree as if it were applicable.

ARARs are generally divided into three categories: chemical specific; location specific; and action specific in accordance with USEPA guidance (USEPA, 1988):

- **Chemical Specific:** Chemical specific ARARs are generally health or risk based numerical values or methods applied to site-specific conditions that results in the establishment of a cleanup level. Many potential ARARs associated with particular response alternative (such as closure) can be characterized as action-specific but include numerical values or methods to establish them so they fit in two categories, chemical-specific and action-specific.
- **Location Specific:** Location specific ARARs are included for environmentally sensitive areas including riparian and other hydrologic resources, and biological and other natural resources are the resource categories relating to location-specific requirements potentially affected by the STSIU remedial actions.
- **Action Specific:** Action specific ARARs are included for the potential remedial actions that will be used in the STSIU.

This classification was developed to aid in the identification of ARARs. Some ARARs do not fall precisely into one group or another. ARARs are identified on a site-specific basis for remedial actions where CERCLA authority is the basis for cleanup.

For the determination of relevance and appropriateness, the pertinent criteria were examined to determine whether the requirements address problems or situations sufficiently similar to the circumstances of the release or response action contemplated, and whether the requirement is well suited to the site. A negative determination of relevance and appropriateness indicates that the requirement does not meet the pertinent criteria.

To qualify as a state ARAR under CERCLA, a state requirement must be:

- A state law or regulation;
- An environmental or facility law or regulation;
- Promulgated;
- Substantive;

- More stringent than federal requirements;
- Identified in a timely manner; and
- Consistently applied.

To constitute an ARAR, a requirement must be substantive. Therefore, in some cases only the substantive provisions of requirements identified as ARARs in this analysis are considered to be ARARs. Permits are considered to be procedural or administrative requirements. Permits are considered to be procedural or administrative requirements, though may contain substantive requirements that are ARARs which must be attained and/or qualify as “to be considered” (TBC) materials that may be used in determining the necessary level of cleanup for protection of human health or the environment. Provisions of generally relevant federal and state statutes and regulations that were determined to be procedural or not environmental in nature, including permit requirements, are not considered ARARs. CERCLA Section 121(e)(1), (42 USC Section 9621(e)(1)), states that “No Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely on-site, where such remedial action is selected and carried out in compliance with this section.” Consistent with 40 CFR, the term “on-site” is defined for purposes of this ARARs discussion as “the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementations of the response action.

In addition to ARARs, non-promulgated advisories, proposed standards, criteria, guidance or policy documents developed by the federal or state government, or other information referred to as TBC materials may also be used in conjunction with ARARs to achieve an acceptable level of risk at a site. Although not legally binding, TBCs may be used when determining protective cleanup levels or response actions where no ARARs exist, or where ARARs alone would not be sufficiently protective of human health and the environment. Because TBCs are not ARARs, their early identification is not mandatory.

The state permit conditions for the Chino Mine shall be considered TBC materials, and considered in the FS for developing remedial alternatives.

Chino had the primary responsibility for identifying federal ARARs for the STSIU. Potential federal ARARs that have been identified for the remediation of STSIU were determined in the RI and are presented in Tables 2-1, 2-2, and 2-3. Pursuant to the definition of the term “on-site” in 40 CFR Section 300.5, the area that is considered part of the remedial action is STSIU (see Section 2.5).

2.3 Remedial Action Objectives (RAOs)

This section identifies the environmental media for the STSIU where potentially unacceptable risks were determined to exist through the risk assessments completed during the RI, as well as the

constituents determined to be responsible for the potential for unacceptable risk. This section also presents the specific RAOs developed for the STSIU for each media of interest.

RAOs are medium-specific goals designed to protect human health and the environment. RAOs serve to focus an FS and provide context for the overall scope of potential cleanup activities at a site. Each RAO specifies: the contaminant of concern; the relevant exposure routes and receptors; and an acceptable contaminant concentration or range of concentrations for each exposure pathway.

The STSIU RI referenced the completed STSIU HHRA and ERA to determine if any constituents present in the environmental media should be considered Constituents of Potential Concern (COPCs). The NewFields ERA (2008b) considered sensitive representative receptors from a number of receptor classes including mammals, birds, plants, and invertebrates. NewFields evaluated direct contact for plants and invertebrates and incidental soil ingestion and food-chain transfer for birds and mammals. The RI also referenced the comprehensive HHRA performed by Gradient (2008) to determine if any chemicals present in environmental media at the site are responsible for potentially unacceptable risk to human receptors in the context of plans for future site use. Accordingly, the human receptor classes evaluated in the HHRA included current resident, future resident, trespasser, construction worker, rancher, industrial worker, recreator swimmer, and trespasser swimmer. Specific pathways considered during the HHRA included direct dermal contact with surface soil, incidental ingestion of surface soil, inhalation of surface soil, dermal contact with surface water, and incidental ingestion of surface water. The risk assessments were implemented according to appropriate guidance and methodologies, which along with the detailed results from the assessments, were previously presented in the STSIU HHRA and ERA reports (Gradient 2008 and NewFields 2008b).

NMED, after reviewing the HHRA and ERA, concluded that arsenic, copper, and iron are potential soil-based risk drivers for at least one human receptor evaluated, and that copper and pCu are potential soil-based risk drivers for at least one ecological receptor evaluated for the STSIU. The Gradient HHRA and NewFields ERA will be discussed in detail in Section 3.1.1.

Based on the findings from the STSIU RI Report, HHRA and ERA (SRK, 2008a, Gradient 2008, NewFields 2008b), the RAOs for the STSIU include:

- Protection of human receptors, as represented by current and future resident or industrial workers, from exposure to arsenic, copper and iron from ingestion of contaminated soil.
- Prevent the ingestion of copper or other site-related metals by the small ground-feeding bird (SGFB) receptor at levels that result in unacceptable population-level risks.
- Toxicity to vegetation or other biological elements of habitat should be reduced to levels that allow for a self-sustaining ecosystem and prevent adverse impacts on local wildlife populations or subpopulations. In areas where habitat function is degraded due to toxicity

of elevated copper concentrations and/or decreased pH from either smelter emissions or contamination released from tailings impoundments, remedial actions should focus on the restoration of wildlife habitat.

- Restore water quality to water quality objectives that are protective of beneficial uses within reasonable timeframe and maintain existing water quality that complies with water quality objectives. RAOs should reduce the likelihood of contact between surface water and soils/sediments that contain heavy metal contaminants at concentrations that could cause deleterious effects to aquatic receptor populations.

2.4 Pre-FS RAC

In a letter dated September 16, 2010 and then amended via a dispute resolution letter dated March 2, 2011, NMED provided Chino with a Pre-FS RAC for the STSIU (NMED, 2010, 2011). Based upon the information documented in the ERA, HHRA, as well as the comments and input provided from all parties, NMED has determined the below Pre-FS RAC values for soil and surface water.

Surface Soil

NMED has determined a Pre-FS RAC for metals that potentially pose human health and ecological risk based on the information documented in the ERA, HHRA, and probability analysis. NMED established HHRA Pre-FS RAC values for arsenic, copper, and iron and ecological Pre-FS RAC values for copper as follows:

- Arsenic: NMED selected the cancer target risk with a Pre-FS RAC of 27 mg/kg. This value is supported by the probability analysis and is consistent with the range of arsenic clean-up levels in previously set in New Mexico by USEPA.
- Copper: NMED selected the non-cancer risk human health Pre-FS RAC as previously determined for the Hurley Soils IU of 5,000 mg/kg copper at private, commercial, and public developed properties. NMED selected the target risk to reduce soil toxicity to plants from copper to be $pCu \geq 5$ where copper is > 327 mg/kg and target risk to reduce soil toxicity to SGFB of 1,600 mg/kg. The SGFB Pre-FS RAC is applicable to the 95 percent upper confidence limit (UCL) on the arithmetic mean concentration of the area-weighted average concentration of copper in surface soil (0-6") within exposure units in the STSIU. In addition, NMED required monitoring for copper concentrations in surface soil between 1,100 and 1,600 mg/kg.
- Iron: NMED selected the non-cancer risk Pre-FS RAC based on the probability analysis of 100,000 mg/kg.

In cases where the above criteria overlap for a given area, the constituent which requires the largest remedial footprint will be considered the “risk driver” and the remedial technology will be selected to address this “driver”. The selected remedial technology will be evaluated to confirm that all “non-risk driver” constituents are in compliance with their respective RACs. With the issuance of the Pre-FS RAC, constituents identified in the RI and risk assessment as COPCs are now considered constituents of concern or COCs. The FS and ROD will be completed consistent with the NCP. Pre-FS RAC are consistent with the use of PRG by EPA in the NCP; therefore, new information can be used to refine the Pre-FS RAC and selection of alternatives (§300.430(e)(2)(i) NCP). Final remediation goals will be determined in the ROD.

Surface Water

NMED selected the Pre-FS RAC for surface water based upon the State of New Mexico Standards for Interstate and Intrastate Surface Waters, Part 20.6.4 NMAC for risk to aquatic life. The Pre-FS RAC for all constituents is Part 20.6.4 NMAC, including all approaches and tools listed in the Code which provide options for site-specific application.

Ground Water

NMED discovered a data gap in the RI Report during the preparation of Pre-FS RAC letter. Drainage sediment sample results exceed the NMED Dilution Attenuation Factors (DAF) developed to protect ground water. Although this potential impact was included in the Conceptual Site Model (CSM) and in the risk assessments, NMED requested Chino to further investigate this potential pathway. NMED requested that Chino collect additional samples from all the drainages that currently exceed the DAF 1 as listed in NMED’s Technical Background Document for Development of Soil Screening Levels, Revision, 5.0 (NMED, 2009) or exceed background concentrations for the following COPCs: arsenic, barium, cadmium, copper, iron, molybdenum, and selenium.

The samples were analyzed using 1) SPLP and 2) Acid-base Accounting (ABA) and the results were compared to Ground Water Quality Standards to determine if this potential pathway may impact groundwater and if potential remedial alternatives should be developed in the FS.

The requested sampling was performed in December 2010 and the results showed that there is no risk associated with sediments leaching to groundwater. Therefore, groundwater will not be evaluated as part of the STSIU FS. The results from the sampling effort were presented in the *Groundwater Quality Pre-Feasibility Study Remedial Action Criteria for Drainage Sediments* (ARCADIS, 2011c).

2.5AOC Study Boundaries

As specifically described in the AOC Scope of Work (NMED, 1994), the STSIU includes all areas containing and proximal to Chino's copper smelter including the slag, all areas containing or which contained facilities ancillary to the primary smelter, and the soil adjacent or impacted by the tailings facility (excluding the Hurley Soils IU). The investigation area is contained in section 31 of T18S, R12W and sections 4, 5, 6, 7, 8, 9, 16, 17, 18, 19, 20, 21, 28, 29, 30, 31, 32, and 33 of T19S, R12W. The above township-range sections, as shown in Figure 2-1, include the town of Hurley, Chino operational area, and all tailings ponds; however, the town of Hurley and the former Hurley Operations Area are excluded from the IU because applicable remediation or closure of these areas are covered under separate regulatory activities. The western extent of the 1994 AOC area is Highway 180, the eastern extent is approximately a quarter mile east of the toe of Tailings Pond 7, and the southern extent is approximately 1 mile south of Tailings Pond 7.

The former Hurley Smelter was decommissioned and demolished in 2007. The former Hurley Operations Area is bounded by the Town of Hurley to the west, Whitewater Creek to the northeast, Lake One to the east, and the tailings impoundments to the south. Current land uses adjacent to the former Hurley Operations Area are residential in the towns of Hurley and North Hurley, tailings disposal south of the operational area, and livestock grazing elsewhere. Chino owns the majority of land included in the STSIU and the majority of this land is currently leased for livestock grazing.

The above investigation area has been expanded over the last 15 years as sampling events have delineated the boundaries of the smelter impacted soils with greater accuracy. The current smelter investigation area now includes areas to the north, east, and west of the original Smelter Investigation Unit located in section 31 of T18S, R12W that have copper concentrations greater than the established background value of 327 mg/kg.

3.0 DESCRIPTION OF CURRENT SITUATION: SOIL

The following sections describe the current understanding of the physical characteristics of the STSIU surface soil based on previous field investigations. Section 3.1 summarizes the conceptual site model, Section 3.2 addresses how the Pre-FS RAC may be applied across the relatively expansive area encompassed by the STSIU as exposure units, and Section 3.3 discusses data gaps identified as a result of the evaluation.

3.1 Conceptual Site Model

The CSM for sources associated with the STSIU was originally presented in the RI Proposal for STSIU (SRK, 2004) as well as in the risk assessments (Gradient, 2008, NewFields, 2008b). Figure 3-1 illustrates a CSM via pathway segments and mechanisms required to understand how potential contamination occurred, including the source, release and transport of mineral processing constituents. Primary sources listed in this CSM are historical mineral processing activities, and tailing impoundments including historical and current facilities.

Soils within the STSIU were affected by historical stack and fugitive dust emissions from historical mineral processing activities associated with the former Hurley Operations area and the tailings area. The AOC Background Report (Chino, 1995) identified the primary sources of contamination in the former Hurley Operations Area resulting from historical smelting, milling, concentrating, and handling of copper bearing material. For the tailings area of the STSIU, the tailings impoundments are considered the primary source of constituents of interest that have the potential to affect environmental media. Both historical and currently operational tailing impoundment may have affected surrounding media; however, DP-214, DP-484 and DP-1340 address any groundwater impacts from the historical or current impoundments due to infiltration to groundwater. Other pathways such as historical run-off and fugitive dust emissions transported constituents in tailings to surrounding soil and drainages. Fugitive dust emissions from the tailings ponds occur when high winds mobilized tailings resulting in transport and subsequent deposition of constituents to the surrounding soil.

Prevailing winds tend to be south-easterly (Chino, 1995); therefore, surface soils in areas to the south and east of the former Hurley Operations Area and the tailings impoundments are likely to be the most affected by dryfall from these aerial sources. Following airborne deposition onto soils, metals and other inorganic constituents may be further redistributed by a combination of physical (air and water erosion) and/or chemical (leaching) processes.

Figure 3-1 identifies the following potential release mechanisms associated with affected surface soil:

- Direct Contact: Exposure associated with direct contact with affected surface soil;

- Re-suspension: Mobilization of affected surface soil to air by wind;
- Run-off: Transport of suspended or dissolved constituents in surface water run-off. Potentially affected sediments may be generated as a result of surface water erosion of surface soil;
- Infiltration: Infiltration of surface water through affected surface soil may potentially release constituents of interest from affected surface soil; and
- Absorption: Constituents from affected surface soil may bioaccumulate in garden foods that could be consumed by persons. In addition, grazing animals, either directly or through plant consumption, could ingest constituents from affected surface soil. Constituents could, in turn, be absorbed through consumption of these animals.

The potential exposure routes for current and future human receptors include:

- Inhalation;
- Ingestion of contaminated food items; and
- Direct contact (ingestion and dermal).

The potential exposure routes for current and future ecological receptors include:

- Direct contact (root uptake and incidental ingestion); and
- Ingestion (contaminated biota).

The above potential human health and ecological exposure routes were evaluated in the STSIU HHRA (Gradient, 2008) and STSIU ERA (NewFields, 2008b). Since the completion and approval of the risk assessments, the STSIU has been impacted by the “white rain” event as described in Section 1.3. This natural event has shifted the geochemistry of the soils and affected the bioavailability of contamination in the STSIU, as documented in the *Year 1 pH Monitoring Report for STSIU* (ARCADIS 2011b).

In addition to the white rain event, Chino submitted closure plans under DP-1340 for the historical tailing impoundments (Tailings Pond 1, 2, B, C, 4, 6E and 6W) and, with closure currently underway, fugitive emissions are being mitigated. Moreover, under DP-1340, Condition 90, an FS was submitted and approved for the closure of Lake One and the Lake One Closure Plan is currently being drafted by Chino and will be submitted to NMED in 2011.

3.1.1 Previous Investigations

The upland soil in the STSIU was evaluated in the STSIU RI (SRK, 2008a), the HHRA (Gradient, 2008), and the ERA (Newfields, 2008b) prior to the development and issuing of the Pre-FS RAC. The following sections summarized the findings of the above three reports.

Remedial Investigation

The STSIU RI Proposal was completed by SRK in 2004 and the RI Report was submitted in 2006 and resubmitted in 2008 with supplemental data (SRK, 2004 and SRK, 2008a). Surface soil samples were taken at 165 locations in the STSIU during the RI sampling efforts (SRK, 2008a).

The RI concluded that copper is the primary metal elevated in surface soils in the STSIU. In addition; arsenic, cadmium, and iron were also detected above the decision criteria, but largely their respective concentrations fall within the range of reference and elevated concentrations and fall within the footprint of copper concentrations. Consistent with conclusions reported in the AOC Background Report (Chino, 1995) and the *Phase II Remedial Investigation Report for the Ecological Investigation Unit* (ARCADIS, 2001), copper concentrations in surface soil exhibit strong spatial characteristics with decreasing concentrations as distance in the direction of prevailing winds increases (SRK, 2008a).

Human Health Risk Assessment

In 2008, Gradient evaluated the risks to human health posed by constituent concentrations in the STSIU. Gradient calculated both cancer risks and non-cancer hazards for potential receptors on the site. The methodology used for this risk assessment was consistent with USEPA guidelines and used conservative, default assumptions, whenever site-specific data were not available. The receptors evaluated in the HHRA included current and future residents, adolescent recreators, adolescent trespassers, ranchers, construction workers, and industrial workers. The upland risk assessment evaluated exposures to soil, windblown dust in air, and locally produced food items.

Gradient indicated that site exposure could result in unacceptable cancer risks for current and future residents. However, these cancer risks are largely driven by the consumption of locally grown foods. Gradient stated that the “consumption of locally grown food” pathway was evaluated using conservative assumptions and tends to overestimate risk. Gradient also found that 90% of the excess lifetime cancer risk is attributed to arsenic. All other receptors (recreators, trespassers, ranchers, construction workers, and smelter workers) did not have unacceptable cancer risk.

The HHRA indicated that site exposures could result in unacceptable non-cancer hazards for residents in all five exposure areas. However, these non-cancer hazards are also largely driven by consumption of locally grown foods. Gradient stated that the “consumption of locally grown food” pathway was evaluated using conservative assumptions and tends to overestimate risk. Furthermore, all residential non-cancer risks in the STSIU were lower than residential RME non-

cancer hazard calculated for the reference area. All other receptors (recreators, trespassers, ranchers, construction workers, and smelter workers) had acceptable non-cancer hazards.

Gradient evaluated copper risks separately using a probabilistic method, only for ingestion of soil. The most sensitive endpoint for copper toxicity is nausea; therefore, copper risks were based on estimating the annual number of nausea episodes that an individual might experience, at a give soil copper concentration. Overall, the industrial worker in the smelter area had the highest copper risk, with an estimated 65 nausea events per year.

NMED established human health RACs for three constituents, arsenic, copper and iron. The arsenic and copper criteria are discussed in Section 2.4.

Ecological Risk Assessment

An ERA was conducted on the STSIU in 2008 (NewFields, 2008b). This ERA evaluated the risks from soil to terrestrial receptors. The methodology used for this risk assessment was consistent with USEPA guidelines, and used conservative, default assumptions, whenever site-specific data were not available. The methodology and parameter selection are described in Technical Memo 1 - ERA Workplan and the sampling and analytical approach are described in Technical Memo 2 (Schafer and Associates, 1999a,b). The Site Wide BERA (NewFields, 2006) was completed and used as a tool to streamline the analysis in the STSIU ERA (NewFields, 2008b). The receptors evaluated in the terrestrial ERA included terrestrial vegetation, herbivorous birds, omnivorous birds, raptors, herbivorous mammals, omnivorous mammals, ruminants, and mammalian predators. The risk assessment evaluated exposures from direct contact, incidental soil ingestion, and ingestion of prey items.

It was concluded that the risks to plants and wildlife were primarily related to elevated copper concentrations and depressed pH in soil (NewFields, 2008b). The risks to the SGFB, the most sensitive receptor evaluated, appear to be elevated in the STSIU due to exposure to copper. The potential for risk, for both plants and the SGFB, is greatest in the areas immediately to the east of the smelter and the tailings impoundments, and decreases with the increased distance to the east of those features.

Since 2008, when the NewFields STSIU ERA was approved by NMED, there has been further analysis of the risk to the SGFB. The following studies and updated exposure parameters have lead to a decrease in predicted exposure levels for the SGFB.

- Ingestion Rate of Food and Soil: The ingestions rates used by NewFields in the ERA were updated to more recent literature algometric values (Nagy, 2001).
- The dose equation was updated to model all potential dietary intakes in dry weight.
- Insect tissue concentrations: Additional insect tissue was collected in 2010 to supplement the tissue that was collected and analysed for in the ERA. The results of this sampling

event are presented in the *Terrestrial Invertebrate Bioaccumulation and Bioavailability Study* (ARCADIS, 2010a). These results were used to update the soil to insect BAF and to more accurately estimate bioavailability from insect tissue.

When the above refinements are incorporated into the dose model for the SGFB, there is a decrease in the predicted exposure associated with the SGFB. The approved Site Wide ERA (Newfields, 2006) documents a prediction of population level risk based on the earlier limited data. With the uncertainties in mind, Chino developed and NMED approved the *Terrestrial Invertebrate Copper Bioaccumulation and Bioavailability Study for STSIU* (ARCADIS, 2010), and subsequently field data were collected with NMED. The results of the data indicate that exposure levels have changed for the SGFB. If the Site-Wide ERA had been formally amended to include such data, the updated exposure parameters would result in lower LOAEL HQs and would update the conclusions of the Site-Wide ERA.

3.1.2 Nature and Extent of Contamination

According to the AOC, the soils of concern in the STSIU are the areas that exceed the Pre-FS RAC values described in Section 2.4 of 5,000 mg/kg copper at 0-1", 1,600 mg/kg copper surface weighted 95 UCL for a habitat unit over 0-6", 27 mg/kg arsenic at 0-1", and 100,000 mg/kg iron at 0-1" or when pCu is less than five with soil copper greater than 327 mg/kg over 0-6". There are six areas excluded from proposed soil remediation for the following reasons:

1. Town of Hurley was addressed in the HSIU and remediated in 2006.
2. Former Hurley Operations Area includes former smelter was demolished in 2007, and the area has been closed under work plans associated with DP-1340.
3. Impacted soils located within the railroad or Highway 180 right-of-ways (ROW). The ROW extends 50 to 100 feet from the railroad tracks on either side and is considered a supporting facility operations area. The ROW extends 50 feet on either side from Highway 180 and is considered by the Department of Transportation (DOT) to be under its management. The impacted soils located within the railroad ROW will be addressed under the facility operations closure plan permit, and the Highway ROW will be addressed by DOT.
4. Areas where previous interim remedial actions have been conducted. Areas that have been previously remediated are not included in the current remediation limits and are not subject to further remedial action. These areas include soil removed as part of a previous interim action conducted in 2008 as summarized in the *STSIU Interim Removal Action Completion Report* (ARCADIS, 2009). Specifically, these areas included; area west of Highway 180, South Golf Course, North Golf Course, Alley Way adjacent to the South Golf Course, area east of Highway 180, and cultural resources located at the end of the South and North Golf Courses. The objective of the interim action was to remove soils where copper concentrations were greater

than 5,000 mg/kg (lateral delineation) at 0 – 1” based on the NMED-approved residential RAC for the Hurley Soils IU. The acres were deemed future residential as extensions of the town of Hurley and fall within the current city limits. At the time, however, within the areas exceeding 5,000 mg/kg, the excavation was completed vertically until the soils did not exceed 2,700 mg/kg. Chino calculated a spatially weighted 95 UCL for the areas included in the interim action of 1,314 mg/kg, which is in compliance of the SGFB Pre-FS RAC of 1,600 mg/kg. The Pre-FS RAC for pCu is based upon the six-inch depth interval because the Ecological IU RI Report and subsequent risk reports document the fact that the acid and copper did not leach deeper than this depth interval and this is the depth most appropriate for ecological receptors. The remediation addressed the top six inches of soil, and copper concentrations were reduced. Since copper concentrations were demonstrated to be coincident with depressed pH along a gradient in the predominant wind direction (Schaffer, 1999; ARCADIS, 2001, Newfields, 2006), the remediation also addressed pH and, consequently, the Pre-FS RAC for pCu.

5. Chino has identified potential portions of the STSIU which may be used as borrow material for Lake One and the tailings closure. Once these areas are identified by Chino and submitted to NMED for approval, they will be considered operation areas and these areas will be managed under approved work plans associated with closure.
6. Cultural resources and jurisdictional wetlands may also warrant exclusion if any are surveyed within the area designated for remedial evaluation.

There are three constituents which exceed NMED’s Pre-FS RAC for soil in the STSIU. Copper and iron have exceedances of the NMED human health criteria, while copper and pCu exceed their respective ecological criteria.

Arsenic

Of the 165 samples collected for the STSIU RI, there are no exceedances of the human health Pre-FS RAC of 27 mg/kg (Table 3-1). Therefore, arsenic will not be evaluated in the STSIU FS.

Copper

There have been approximately 300 surface soil (0-1” bgs and 0-6” bgs) taken in the STSIU through December 2010. These samples were taken as part of the AOC Background Report (Chino, 1995), Site Wide ERA (NewFields, 2006), STSIU RI (SRK, 2008a), pH monitoring samples (ARCADIS, 2011b), and amendment study samples (ARCADIS, 2011a).

The risk from copper in the STSIU is driven by the risk to ecological receptors; therefore, the soil horizon of concern is 0-6” bgs. Historically most copper samples were sampled from the 0-1” bgs interval to determine potential risk to human health. The copper results from the 0-1” were adjusted to 0-6” using the median ratio between the two depths (Table 3-2 and Appendix A). This adjustment allowed a more extensive 0-6” dataset to determine potential remedial areas. The above

combined dataset was used to develop Figure 3-2, showing Chino's current understanding of copper distribution in the STSIU. As presented in Figure 3-2, copper concentrations are the greatest to the east of the historical smelter and decrease with increased distance from the historical smelters location. There are also areas of elevated copper on the north, south, and west of the town of Hurley from smelting and other historical mineral processing activities. Similar to the elevated areas to the east, copper concentrations to the north, south and west decrease with increased distance from Chino's operational area. The extent of exceedances will be further delineated through increased sampling prior to the FS as presented in Appendix A (Upland Sampling Work Plan) of this Proposal.

Iron

Two of the 165 soil samples collected for the RI and analysed by EPA 6010 exceed the human health Pre-FS RAC of 100,000 mg/kg (Table 3-1). The location of these samples (SS145 & SS148) is along the eastern border of Tailing Dam 7 as seen in Figure 3-3. The iron results from SS145 & SS148 only slightly exceed the human health Pre-FS RAC with concentrations of 141,000 mg/kg and 123,000 mg/kg, respectively. The extent of exceedances is adequate to evaluate remedial alternatives the FS.

pCu

There have been 61 pCu samples taken in the STSIU through December 2010. These 61 samples are being supplemented by calculated pCu values using the following equation provide by Sitewide ERA (NewFields, 2006) for upland locations that contain copper and pH results:

$$pCu = 6.16 + (1 * pH) - (1.02 * \ln[Cu_{tot}])$$

As discussed in Section 1.2, Chino is currently monitoring 22 locations for changes in pH, copper, and pCu as a result of the White Rain event in January of 2008. The monitoring of the three constituents started in 2010 and will be conducted over five years finishing in 2014. The results from the first monitoring event were presented in *Administrative Order on Consent Year 1 pH Monitoring Report* (ARCADIS, 2011b).

The current extent of $pCu < 5$, using the two data sources above, can be seen in Figure 3-4 and Table 3-3. As shown on Figure 3-4, there are potential exceedances of the Pre-FS RAC to the east and southeast of Hurley and to the east of Tailings Pond 6E. The extent of exceedances will be further delineated through increased sampling prior to the FS as presented in Appendix A of this work plan and the continuation of the pH monitoring sampling.

3.2 Exposure Units

As discussed in Section 2.4, the March 3, 2011 NMED Chino AOC Informal Dispute Resolution STSIU memo states that the copper SGFB Pre-FS RAC value of 1,600 mg/kg is intended as

95UCL area-weighted average concentration within an exposure unit, and exposure unit should be delineated based on habitat. The term "habitat unit" has not been defined for the AOC; therefore, to better understand the potential habitat units in the STSIU, aerial photographs as well as remote sensing imagery will be used and a percent of the habitat units described via a desktop evaluation will be field verified in order to calibrate the images to a more practical application. The results from this evaluation will be used as a line of evidence to determine habitat units in the STSIU. The details of the exposure unit delineation and field verification are presented in the Upland Sampling Work Plan (Appendix A).

3.3 Data Needs

Section 3.1.2 presents Chino's current understanding of the extent of contamination in the STSIU. Chino believes additional sampling is needed to refine the potential remedial areas for all constituents that exceed their respective Pre-FS RACs. As described above under Section 3.1.2, Chino is proposing additional soil samples be collected to more accurately define the current extent of contamination for copper and pCu in surface soil. The exact sampling locations and methods are presented in the Upland Sampling Work Plan (Appendix A).

Additionally, as described in Section 3.2, Chino is proposing to delineate exposure units via desktop evaluation with field verification. The Upland Sampling Work Plan (Appendix A) also describes the methodology that will be used to perform rangeland and drainage habitat surveys to better understand the potential habitat units in the STSIU. NMED requires that the SGFB copper Pre-FS RAC be applied as a 95UCL spatially weighted average over a habitat unit. Through remote sensing with field verification, SGFB habitat units will be defined for the STSIU and presented in the FS Report.

Concurrent with the above sampling efforts, the Lake One Closure Plan will be submitted to NMED in 2011, and the work plan will include areas designated for borrow. Once NMED approves this work plan, borrow areas will be considered operational areas and evaluated as such in the STSIU FS Report.

4.0 DESCRIPTION OF CURRENT SITUATION: SURFACE WATER

4.1 Conceptual Site Model

As discussed in the AOC Background Report (Chino, 1995) and the STSIU RI (SRK, 2008a), the surface waters¹ and drainages in the STSIU include Bolton Draw, Rustler Canyon, Martin Canyon, and other un-named tributaries of Whitewater Creek and Lampbright Draw. These drainages are commonly considered ephemeral, with surface water flow generally occurring during and immediately after a precipitation event (Figure 4-1). Other than these drainages, the remaining surface water bodies present in the STSIU are livestock watering tanks and a small number of persistent pools in some of the STSIU drainages. Chino submitted a work plan to conduct a Hydrology Protocol completed in June 2011 and the results will be incorporated into the FS. The livestock tanks are generally designed to catch surface water run-off and/or spring or well water, and to hold water for extended periods of time. There are more than 20 small to large sized tanks throughout the STSIU.

Fate and Transport of COCs in STSIU Drainages

The primary sources of surface water impacts in the STSIU drainages are due to the presence of COCs in surface water run-off, leaching of COCs from sediments, and re-expression of potentially impacted alluvial water (Figure 3-1).

Surface Water Run-off

For the STSIU drainages, run-off from the upland environment is considered to be a source of potential COC impacts to surface water. COCs from impacted soils, from either smelter emissions or fugitive dust, have the potential to be suspended or dissolved in run-off during precipitation events, leading to increased total and dissolved surface water concentrations of COCs in the receiving drainages.

Leaching from Sediments

STSIU surface water also has the potential to be affected by the remobilization of COCs from legacy sediments in drainages during stream flow events. Constituents in COC-impacted sediments, derived from smelter emissions, historical upland run-off, or fugitive dust, may be remobilized during precipitation events, leading to possible increased dissolved surface water COC concentrations in the receiving drainages.

¹ The term “surface waters” is used in this document to reflect the common meaning of the term, not any legal meaning. Use of this term is not intended to imply that there has been a determination that any particular surface water or drainage constitutes a “surface water of the state” or “waters of the United States.”

The leaching potential of sediments in STSIU drainages was evaluated for samples collected at select locations within the STSIU during a December 2010 sampling event and reported the results in the *Groundwater Quality Pre-Feasibility Study Remedial Action Criteria for Drainage Sediments* (ARCADIS 2011c). These results demonstrate that, with the exception of copper, sediments in the STSIU drainages do not have the potential to leach COCs to surface water at concentrations that may adversely affect the surface water quality at concentrations above acute aquatic life criteria. Additional data needs for copper are described in Section 4.2.

Re-emergence of Subsurface Alluvial Water

There are a few locations in the STSIU where subsurface alluvial water is re-expressed as surface water via seeps. If this re-expressed groundwater has COC concentrations that are greater than the NM Water Quality Standards (WQS), then there is a potential that this subsurface alluvial water could have implications on how to manage surface water.

Currently, it is unclear which of these fate and transport mechanisms is driving metals – and specifically copper – loading to STSIU drainages, although a hypothesis is that metals in surface soil may drive the copper concentrations in run-off to drainages. Appendix B provides a separate work plan for further understanding the CSM of STSIU drainages. This work plan includes the use of stormwater samplers that sample run-off, and the data will be used to allocate metals load in surface water to upgradient sources, soil sources or legacy sediment sources.

Fate and Transport of COCs in Stock Tanks

Stock tanks that receive the majority of their water from surface run-off are a key focus for the CSM since the COC sources described above for surface water will contribute to the stock tanks' water quality. Tanks may also receive water from springs or windmill-pumped groundwater but these tanks do not have a large surface water run-off component. The water quality in stock tanks will also be affected by the potential regeneration of COCs stored in stock tank sediments.

Cycling of COCs from Sediments

For stock tanks, the cycling of COCs from sediment to surface water is considered to be a primary source of COC impacts. When a stock tank has an inflow of water from a storm event, the constituents in the sediment have the potential to remobilize. If the constituent is easily remobilized, there is a potential for this constituent to increase in concentration for each inflow event. This increase in concentration is a result of the water in the stock tank evaporating over time, yet with no outflow the concentrations increase as the water level decreases. When a new inflow event occurs, the already present mass of COCs in the stock tank is increased by the constituents present in the incoming surface water. The combination of COC-impacted surface water and the remobilization of COCs from COC-impacted sediments in the stock tanks results in the potential for COCs in stock tank water to exceed surface water criteria.

Surface Water Run-off

Stock tanks receive the majority of their water from surface drainages, which in turn receive the majority of their water from surface run-off. As stated above, there is potential for COCs in soils to be suspended or dissolved in run-off during precipitation events, leading to increased total and dissolved surface water COC concentrations and COC mass in the receiving stock tanks.

Leaching from Sediments

As mentioned above, stock tanks receive the majority of their water from surface drainages. When water is present in the drainages, there is potential for COCs to become remobilized from legacy sediments. COCs from smelter emissions, historical upland run-off, or fugitive dust, can become remobilized, leading to increased surface water COC concentrations and COC mass in the receiving stock tanks.

Currently, it is unclear which of these fate and transport mechanisms is driving metals – and specifically copper – loading to STSIU stock tanks, although a hypothesis is that legacy sediment at the base of the tanks drives the copper concentrations in surface water. Appendix B provides a separate work plan for further understanding the CSM of STSIU stock tanks. This work plan includes the use of stormwater samplers that sample run-off and the data will be used to allocate metals load in surface water to upgradient sources, soil sources or legacy sediment sources.

Surface Water Conceptual Site Model

STSIU surface water, contained in drainages and stock tanks, has the potential to be affected by surface soil run-off, COC-impacted legacy sediments, regeneration of COCs from sediments, and potentially COC-impacted subsurface alluvial water expressing in seeps. Figure 3-1 illustrates the CSM for the STSIU surface water. The CSM identified the following potential release mechanisms associated with COC-impacted surface water:

- Direct Contact: Exposure associated with direct contact with affected surface water;
- Ingestion: Exposure associated with ingestion of affected surface water; and
- Absorption: COCs from affected surface water may bioaccumulate in foods that could be consumed by grazing animals. COCs could, in turn, be absorbed through consumption of these animals.

The potential exposure routes for current and future human receptors include:

- Direct contact (ingestion and dermal).

The potential exposure routes for current and future ecological receptors include;

- Direct contact (dermal contact); and
- Ingestion (contaminated biota and drinking water)

The above potential human health and ecological exposure routes were evaluated in the STSIU HHRA (Gradient, 2008) and ERA (NewFields, 2008b).

4.1.1 Previous Investigations

Remedial Investigation

The STSIU RI was completed by SRK in 2004, and then revised with the inclusion of new data and resubmitted in 2008 (SRK, 2004 and SRK, 2008a). Twenty four surface water samples were collected at 16 locations in the STSIU and were used to evaluate surface water quality during the RI (SRK, 2008a). These results were presented in the Addendum to the RI (SRK, 2008b).

During the RI sampling, aluminium, barium, beryllium, boron, cadmium, calcium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, vanadium, and zinc were detected in STSIU surface water. Of these detected constituents, only cadmium, copper, and lead were detected at concentrations that exceeded the chronic aquatic life criteria (SRK, 2008b).

Human Health Risk Assessment

The 2008 Gradient HHRA evaluated data generated from surface water samples collected within the STSIU. The risk assessment calculated cancer risks and non-cancer hazards for potential receptors on the site. The methodology used for this risk assessment was consistent with USEPA guidelines, and used conservative, default assumptions, whenever site-specific data were not available. Gradient evaluated two scenarios, the recreator swimmer and the trespasser swimmer, to determine the potential risk from exposure to STSIU surface water.

Gradient determined that site exposure to surface water did not result in unacceptable cancer risks or non-cancer risks for either the recreator swimmer or the trespasser swimmer scenarios for any COCs identified for the STSIU.

Ecological Risk Assessment

During the RI sampling, aluminium, barium, beryllium, boron, cadmium, calcium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, vanadium, and zinc were detected in STSIU surface water. Of these detected constituents, only cadmium, copper, and lead were detected at concentrations that exceeded the chronic aquatic life criteria (SRK, 2008b). Lead concentrations were not detected above the acute aquatic life criteria. Cadmium concentrations exceeded the acute criteria in three drainage locations and two stock tanks. Copper concentrations exceeded the acute criteria in drainage and stock pond locations.

NewFields conducted an ERA of the STSIU in 2008 (NewFields, 2008b). The NewFields' ERA evaluated the risks from surface water to aquatic receptors. The methodology used for this risk assessment was consistent with USEPA guidelines and used conservative, default assumptions, whenever site-specific data were not available. The receptors evaluated in NewFields' ERA included amphibians, aquatic invertebrate communities, and fish communities. NewFields only evaluated direct contact exposure for the above aquatic receptors.

The ERA showed that where surface water exists in the STSIU, the COCs of most concern were cadmium, copper, and lead (NewFields, 2008b). These three constituents exceed the chronic aquatic life NM WQS and/or the selected amphibian TRVs (Harfenist et al 1989 and Schafer and Associates 1999a) at one or more RI surface water locations.

NewFields concluded that where water is present in the STSIU, copper concentrations are elevated above acute and chronic water quality criteria at most locations (NewFields, 2008b). Potentially significant risks to aquatic life from copper in surface water are predicted for the limited aquatic habitat within the STSIU. However, the risks to aquatic receptors from chemical exposure need to be qualified given the overall physical quality of the aquatic habitat. Without persistent aquatic habitat in the area, aquatic life is limited to invertebrate species that breed in water, and potentially breeding and larval amphibians particularly in the stock tanks. Therefore, as stated by NewFields, the risk estimations presented for aquatic life are highly uncertain (NewFields, 2008b).

4.1.2 Nature and Extent of Contamination

Using the results presented in the 2008 RI Addendum, there were only three constituents that exceeded a surface water criterion in the STSIU (SRK, 2008b). Cadmium, copper, and lead all had exceedances of their respective chronic aquatic life NMWQC, while only cadmium and copper had exceedances of their respective acute aquatic life NMWQC. Since the RI and human health and ecological risk assessments were accepted in 2008, New Mexico has updated their water quality criteria during their 2010 triennial review. The below nature and extent section is based on the most recent §20.6.4.900I NMAC.

Cadmium

There are four surface water locations in the STSIU that exceed the hardness corrected acute aquatic life NMWQC for cadmium. Two of these locations are in drainages (Drainage C and Bolton Draw) and the other two locations were stock tanks (ERA-40 and ERA-41) (Figure 4-2). As shown in Table 4-1, all exceedances of the hardness adjusted acute criterion for cadmium were slight, with the exception of Bolton Draw.

Copper

There were copper exceedances of the hardness-adjusted acute aquatic life NMWQC in all surface water samples collected at stock tanks, A-Drainage, B-Drainage, C-Drainage, D-Drainage, and Bolton Draw sampling locations. The exceedances of the acute aquatic life criterion in the stock tank samples were generally low (Table 4-2). As shown on Table 4-2, there were exceedances of the acute aquatic life criteria in all drainages, with the maximum exceedance observed for the sample collected from the C-Drainage. Figure 4-3 shows all surface water sample locations that had an exceedance of the hardness-adjusted equations for copper.

Lead

When the updated lead acute and chronic aquatic life criterion is applied to the RI samples, there are no exceedances of the hardness adjusted aquatic life criterion in the STSIU (Table 4-3). Therefore, lead will not be evaluated in the STSIU FS.

4.2 Data Needs

The NMED Pre-FS RAC for metals in surface waters was based on Part 20.6.4 NMAC, including all the tools and approaches listed in the Code which provide for site specific application. Based on a preliminary evaluation conducted in 2010, it is clear that the vast majority of these streams meet the characteristics of ephemeral waters. The Statewide Water Quality Management Plan and Continuing Planning Process (WQCC, 2011) provides a decision tree for expedited use-attainability analysis (UAA) Process for unclassified ephemeral streams (see Figure II-2 in WQCC, 2011). Chino developed hydrology work plan to provide determination of hydrologic regime for tributary channels within the STSIU sub-watersheds. The objectives of the hydrology work plan include (1) conducted expedited UAA for STSIU drainages based on application of New Mexico's Hydrology Protocol and (2) conduct formal UAA for stock tanks within STSIU. These work plans were submitted to the Surface Water Quality Bureau on a parallel track to this STSIU FS Proposal.

For most metals, criteria are expressed as a function of site-specific water hardness; however, these hardness-adjusted criteria do not account for other key chemical parameters that potentially alter metal bioavailability and toxicity. As such, other options are available to derive site-specific water quality criteria. Section 131.11 (b) (ii) of the federal water quality standards regulation (40 CFR Part 131) provides the regulatory mechanism for a State to develop site-specific criteria for use in water quality standards. Further, as a result of New Mexico's Triennial Review of surface water standards, new provisions are available for establishing segment-specific surface water criteria. As specified in §20.6.4.10.D NMAC, site-specific criteria may be developed when physical or chemical characteristics at a site alter the bioavailability or toxicity of a chemical. Site specific criteria may be derived from one of the following procedures: water effect ratio (WER), biotic ligand model (BLM), recalculation procedure, or the resident species procedure.

Based on the current criteria in §20.6.4.10 NMAC and a preliminary review of Chino's surface water chemistry, WER and/or BLM procedures are appropriate for deriving site-specific metal

criteria for surface waters at Chino. The criteria-adjustment work plan was also submitted to the Surface Water Quality Bureau concurrent with this STSIU FS Proposal and findings may result in a rulemaking petition. The work plan describes studies that will be used to understand the site-specific toxicity of copper in STSIU surface waters. These studies are based on scientifically-defensible methods described in §20.6.4.10 NMAC, and are designed to incorporate the effects of site-specific water chemistries on the bioavailability and toxicity of copper to aquatic organisms. It is further envisioned that results from these criteria-adjustment studies will provide the data necessary for the establishment of site-specific copper criteria.

In addition to these studies, Appendix B provides a separate work plan for further understanding the conceptual site model of STSIU drainages and stock tanks. This work plan includes the use of stormwater samplers that sample run-off and the data will be used to allocate metals load in surface water to upgradient sources, soil sources or legacy sediment sources.

5.0 REMEDIAL TECHNOLOGIES: SOIL

As part of this FS Proposal, a range of potential soil remedial technologies have been identified and summarized for the upland areas of the STSIU. In 2006, an extensive literature search was conducted consisting of a review of over 500 abstracts related to potential soil remedial technologies for treatment and/or removal of the primary constituent of concern for the site (copper). As a result of this review, 12 technologies have been identified and included in this FS Work Plan as Table 5-1 for a preliminary screening and evaluation. The preliminary screening and evaluation of the potential soil remedial technologies has been performed to determine which remedial technologies should be retained for consideration as part of the FS, which will include a comprehensive alternatives evaluation for remedial alternatives for the site. The preliminary screening of each remedial technology is based on USEPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA, 1988) and includes an evaluation of the effectiveness, implementability, and cost. Potential use of institutional controls, consistent with CERCLA guidance (EPA 2010) may be warranted for implementation of specific remedial technologies as described below.

Based on the preliminary screening, if the remedial technology is considered viable, it will be retained for consideration as part of the site-wide remedial alternatives analysis. A detailed evaluation will be conducted for each potential remedial alternative in the FS, to be developed following the completion and acceptance by NMED of this FS Proposal. The FS will present a remedial alternative analysis based on the full list of EPA evaluation criteria, including:

- overall protection of human health and the environment;
- compliance with ARARs;
- long-term effectiveness and permanence;
- reduction of toxicity, mobility, or volume;
- short-term effectiveness;
- implementability;
- cost-effectiveness;
- NMED acceptance; and
- community acceptance.

In addition to the above standard EPA evaluation criteria, the remedial alternatives will be evaluated using green remediation criteria. Factors for each remedial alternative that will be

evaluated may include, but may not be limited to, conservation of natural resources, carbon footprint, greenhouse gas emissions, and sustainability of the design.

The soil remedial technologies that have been identified for evaluation and preliminary screening in this FS Proposal include the following:

- No Action;
- Monitoring;
- Excavation and Reuse;
- Excavation and Disposal;
- Soil Amendments – Limestone and Organic Matter;
- Soil Amendments – Tilling;
- Soil Amendments – Ferrihydrite;
- Soil Amendments – Chelating Agents;
- Containment – Soil Cover;
- Containment – Impermeable Cover;
- Surface Soil Controls: Phytostabilization;
- Phytoremediation; and
- Electrokinetic Remediation.

A detailed explanation of these soil remedial technologies and a preliminary screening of each technology are included below.

5.1 No Action

This remedial technology consists of leaving the site soils in their current condition without performing any soils/vegetation removal or treatment, engineering controls, or institutional controls as part of the remediation efforts. This technology is provided as a baseline for screening other technologies and is summarized as Technology No. 1 in Table 5-1.

Preliminary Screen

Effectiveness

Site-contaminants will naturally attenuate over the course of time. Natural attenuation has been documented recently at the site after the 2008 White Rain event which contributed to an increase in the soil pH levels. But for the White Rain event, this remedial technology does not provide active mechanisms to reduce the short- and mid-term exposure of the soil constituents to site receptors; however, the White Rain event did provide a short and mid-term reduction in risk but it is unknown how permanent the effect actually will be and monitoring will provide an indication of its long-term effectiveness. Therefore, while this remedial technology generally may have overall low effectiveness in reducing potential risk to site receptors, the effect of the White Rain may show moderate or high effectiveness as monitoring proceeds and, as discussed in Section 3.1.1, the overall predicted exposure to the SGFB has decreased since the finalization of the ERA.

Implementability

There are no remedial activities associated with this technology and therefore, this remedial technology is considered highly implementable.

Cost

There are no costs associated with this remedial technology. Costs associated with no action are considered low.

Screening Result

No Action is being retained as a baseline for comparison with other remedial technologies in the FS and for potential use in conjunction with other technologies where implementability may be low.

5.2 Monitoring

This remedial technology consists of leaving the site soils in their current condition without performing any soils/vegetation removal or treatment, engineering controls, or institutional controls as part of the remediation efforts. As part of this technology, a monitoring program would be implemented to observe and document the occurrence of natural attenuation of site contaminants. Monitoring would include collection of qualitative and quantitative samples of STSIU media such as surface soils, vegetation and other biotic media. This technology is provided as a baseline for screening other technologies and is summarized as Technology No. 2 in Table 5-1.

Preliminary Screen

Effectiveness

Site contaminants will naturally attenuate over the course of time. Natural attenuation has been documented recently at the site after the 2008 White Rain event which contributed to an increase in the soil pH levels. But for the White Rain event, this remedial technology does not provide active mechanisms to reduce the short- and mid-term exposure of the soil constituents to site receptors; however, the White Rain event did provide a short and mid-term reduction in risk but it is unknown how permanent the effect actually will be and monitoring will provide an indication of its long-term effectiveness. Therefore, while this remedial technology generally may have overall low effectiveness in reducing potential risk to site receptors, the effect of the White Rain may show moderate or high effectiveness as monitoring proceeds.

Implementability

Activities associated with this technology include establishing a monitoring program and, therefore, this remedial technology is considered highly implementable.

Cost

Costs for this remedial technology are associated with development and implementation of a monitoring program. Costs will vary slightly depending on types of monitoring (quantitative and qualitative) and duration of monitoring period selected. Costs associated with monitoring for natural attenuation are considered low.

Screening Result

Monitoring is being retained as a baseline for comparison with other remedial technologies in the FS and for potential use in conjunction with other technologies where implementability may be low.

5.3 Excavation and Reuse

This remedial technology consists of removal of soils with contaminants above the soil RAC levels located 0- to 6-inches below ground surface (bgs). Depth of removal could vary depending on site features such as the presence of bedrock. Final lateral and vertical removal extents would be determined during the remedial design. This technology would remove soils considered to be impacted for final onsite management at the waste rock stockpiles or for future use as soil cover material for the Chino Mine tailings pond closure activities or other operational areas of the site. This technology is summarized as Technology No. 3 in Table 5-1.

Excavation Approach

Soil scraping/removal and transport onsite would be conducted using general heavy construction equipment/mechanical means such as excavators, loaders, and potentially soil vacuum removal equipment. However, physical site factors, such as depth of soil, extent of vegetation, surface slopes, equipment and personnel accessibility, and availability of upland areas for soils staging and processing will influence the final selection of construction equipment to be utilized.

Prior to soil excavation, surface materials such as vegetation and boulders, would be cleared and stockpiled along the perimeter of the work areas. It is anticipated that cleared materials would be used to provide cover for birds and animals in the area. Depending on the extent and type of vegetation present, vegetation could also be reduced in size and chipped for potential onsite use as ground cover throughout the duration of construction to minimize fugitive dust generation.

Removed soils would be staged at designated areas to be determined during development of the remedial design. Removed soils associated with historical smelter emissions will be characterized in accordance with Resource Conservation and Recovery Act (RCRA) regulations to determine suitability for reuse as cover material for the Chino Mine tailings ponds, or other operational areas.

In the areas where removal of soils and overlying vegetation would occur, the newly exposed surface will generally consist of bedrock and/or soils with copper levels below the soil RAC. The excavated areas may be left at post-excavation grades, or may be backfilled with approved imported or borrow area soils, stone, and/or riprap. The type and extent of soil replacement material, including the final elevations, shall be determined during the remedial design phase of the project. The excavation areas will be final graded to promote positive drainage (i.e., limited sinks or low points).

Best Management Practices (BMPs) would be applied throughout the duration of construction to minimize erosion due to wind, rain, and sedimentation from the work areas. Selected BMPs would be determined during the remedial design and will vary depending on condition of the work area surroundings (i.e., slopes, presence of bodies of water, roads, etc) and lateral extent of excavation.

Preliminary Screen

Effectiveness

Excavation is considered highly effective at reducing the concentration of contaminants in site soils. However, the net environmental benefit of removing all soil and vegetation to reduce risk may not outweigh leaving the soil in place and using some alternate technology since this technology is extremely intrusive to wildlife inhabiting the area.

Implementability

Excavation of impacted soils is generally considered to be a technically implementable technology for removal of site contaminants at most areas of the STSIU. However, factors that reduce the implementability of this remedial technology include equipment and personnel accessibility to some portions of the site and generation of fugitive emissions throughout the duration of material disturbance, heavy construction and material transport activities.

Cost

Excavation costs include equipment use and maintenance, material handling onsite, material transport and final management at the waste rock stockpiles or placement as cover material for the Chino Mine tailings ponds or other operational areas, and imported backfill and placement (if required).

Screening Result

Soil excavation could be applied at the site for the overall site-wide remedy or applied at targeted locations with higher concentrations of contaminated soils in conjunction with another technology. Although this technology may not be implementable at all areas, this technology is being retained due to its high effectiveness at reducing site contaminants.

5.4 Excavation and Disposal

This remedial technology consists of removing soils above the soil RAC levels in the same manner as described in the excavation and onsite management remedial technology described in Section 5.2. However, instead of final onsite management of soils at the waste rock stockpiles or re-using the removed soils for cover material in the operational areas of the site, the soils would be disposed of at an offsite commercial disposal facility.

Removed soils would be characterized in accordance with RCRA regulations to determine final offsite transportation and disposition requirements. This technology is summarized as Technology No. 3a in Table 5-1.

Preliminary Screen

Effectiveness

Excavation is considered highly effective at reducing the concentration of contaminants in site soils. However, the net environmental benefit of removing all soil and vegetation to reduce risk may not outweigh leaving the soil in place and using some alternate technology since this technology is extremely intrusive to wildlife inhabiting the area.

Implementability

Excavation of impacted soils is generally considered to be a technically implementable technology for removal of site contaminants at most areas of the STSIU. However, factors that reduce the implementability of this remedial technology include equipment and personnel accessibility to some portions of the site and generation of fugitive emissions throughout the duration of material disturbance, heavy construction and material transport activities. In addition, disposal at an offsite commercial disposal facility would be feasible if the facility is permitted to receive the contaminated soil and if it is sufficiently close to allow for economic transport. However, commercial disposal facilities have not been identified that meet these criteria (permitted to accept waste to be generated and sufficiently for economic transportation); therefore, offsite transportation of the excavated soils is considered to have low implementability.

Cost

Excavation costs include equipment use and maintenance, material handling onsite, material transport and offsite transportation and disposal, and imported backfill and placement (if needed). Additional costs associated with soil sampling and characterization, and soil treatment to meet Landfill Disposal Restrictions (LDRs), if applicable, may be required prior to disposal. Because there are not permitted disposal facilities located within an economical distance of the site, the transportation costs are considered very high as compared to excavation and onsite management or reuse.

Screening Result

Soil excavation could be applied at the Site for the overall site-wide remedy or applied at targeted locations with higher concentrations of contaminated soils in conjunction with another technology. Although this technology may not be implementable at all areas due to transportation cost for off-site disposal, this technology is being retained for further analysis in the FS.

5.5 Soil Amendments – Limestone and Organic Matter

Many soil amendment technologies exist for reducing metals bioavailability, toxicity, and mobility in soils. They rely on changing soil chemistry to affect the solubility or mobility of site contaminants within the soil column, and/or improve vegetative cover or speciation. Several soil amendments are described further below including: pH adjustment via lime addition and/or organic matter, tilling (Section 5.5), ferrihydrite (Section 5.6) and chelating agents (Section 5.7). The pH adjustment and/or organic matter addition technology is summarized as Technology No. 4a in Table 5-1.

Soil amendment technologies are currently being evaluated as part of an Amendment Study at four separate areas onsite as described in the Amendment Study Work Plan (ARCADIS, 2008a). The

combinations of soil amendments being tested include the application of lime slurry and/or organic matter, and/or soil mixing. The selection of the lime slurry, organic matter, and soil mixing combinations for the Amendment Study were based on the initial technology screen and abstract review that was conducted in 2006. The Amendment Study is being conducted over a period of 5 years, was initiated in 2009, and is currently entering the third year of the study.

Each test area consists of a ¼ acre section and had pre-treatment copper levels in soils ranging from 2,700 mg/kg to 5,000 mg/kg. The following soil amendment technologies are being tested at each particular test area:

- West Plot (West of Hurley): No technologies applied, considered a baseline control plot.
- North Plot (North of Hurley): Spray application of lime slurry, tilling of the soil, and addition of organic matter.
- Northeast Plot / East A (Northeast of Hurley): Spray application of lime slurry and addition of organic matter.
- East Plot / East B (East of Hurley): Spray application of lime slurry, tilling of the soil, and addition of organic matter.

Amendment Study area is currently being monitored on a semi-annual basis. Semi-annual monitoring activities consist of the following:

- Collecting soil samples for analysis. Soil is collected at depth intervals of 0- to 6-inches below ground surface (bgs) and 18- to 24- inches bgs. Samples are analyzed for pH, calcium, nitrogen, potassium, total organic carbon (TOC), total copper, copper solubility via SPLP, and ABA; and
- Inspection and maintenance of BMPs, as needed.

In addition, measuring percent cover of vegetation, number of species, and community composition, proportion of vegetation in different life forms, and shrub density will be conducted during Year 1 and Year 5.

As included in the Amendment Study Work Plan (ARCADIS, 2008a), data collected over the five years of monitoring will be assessed to determine if a particular amendment, or combination thereof, can be successfully applied to particular areas at the Site. In summary, the success of the Amendment Study will be determined based on the following criteria:

- Reduced solubility of copper within the top six inches of soils as compared to pre-amendment baseline conditions;

- Sustained pH levels within the target range of 5.5 to 6.5 during the five-year monitoring period;
- Increase plant coverage percentage as compared to reference sites and the control plot. Percent cover of native species between 70 and 100 percent of the baseline observed at the reference sites will be considered a successful re-growth during the first two years following implementation; and
- Improved soil chemistry (i.e., carbon to nitrogen [C/N] ratio and concentration and nutrients) is sustained over the monitoring period. Improved chemistry is assumed to have been achieved if the C/N ratio after amendment is less than 20:1. Sustainability of the improved C/N ratio is the true metric for performance and permanence.

Preliminary Screening

Effectiveness

Because the Amendment Study is currently in progress and has only completed two out of the five years of the study, the overall effectiveness of lime or organic material amendments as a remedial technology will be determined upon completion of the Amendment Study.

Implementability

Soil amendment has been demonstrated in the Amendment Study to be a technically implementable technology onsite. Factors that reduce the implementability include equipment and personnel access to certain portions of the site (steep slopes, barriers, etc.) and generation of fugitive emissions throughout the duration of the material disturbance resulting from the soil amending process and material transport activities.

Cost

Overall costs of the soil amendment technology will depend on the results of the Amendment Study. However, less soil handling is required as compared to excavation. Soils remain at STSIU and are treated in place which will minimize transportation and imported backfill costs.

Screening Result

Soil amendment using lime or organic matter will be retained as a remedial technology to be considered as part of the comprehensive remedial alternative for further evaluation in the FS.

5.6 Soil Amendments - Tilling

Soil mixing by using mechanical tilling technology is being evaluated as part of this FS Work Plan for use at the site as part of the comprehensive remedial alternative. This technology does not include the addition of other amendments such as lime and/or organic matter; however, the subsurface soil at STSIU may include gila conglomerate which has high alkalinity and geochemistry that may serve as a naturally-occurring amendment. Tilling will be conducted in a similar manner as performed in the soil amendment study. Initially, the ground surface vegetation is cleared and grubbed using a bulldozer and/or excavator. Following vegetation clearing, the tilling is conducted using a 140 blade (or similar) attached to a bulldozer to mix to a pre-determined depth of soil. In areas requiring soil mixing with limited access to larger equipment, hand tilling equipment can be used as an alternative to the bulldozer to mix soils.

Tilling has the potential to provide additional attenuation of metals and to raise pH conditions to more neutral pH conditions pending existing pH levels within the soil treatment area being tilled. Plant coverage, pH, and soil chemistry would be monitored post-tilling operations. As part of the remedial design phase, additional soil sampling (contaminant levels and soil chemistry) within the soil treatment column would be conducted to determine if tilling alone would be appropriate technology and what is the appropriate soil mixing depth within each soil treatment area to raise pH conditions. The soil amendments - tilling technology is summarized as Technology No. 4b in Table 5-1.

Preliminary Screen

Effectiveness

Is potentially effective at raising pH conditions by mixing lower pH soils with higher pH soils and making contaminants less bioavailable to site receptors without the introduction of lime and/or organic matter. Tilling could also reduce COC concentrations by mixing the higher concentration surface materials with deeper soils that have lower concentrations.

Implementability

Mixing soils by tilling has been demonstrated to be implementable at the site via the ongoing amendment study. This technology will be less implementable at areas of the site that are not readily accessible by equipment for tilling (i.e., areas with too steep of a slope) or areas where there is not enough soil coverage to be conducive to soil mixing before encountering bedrock.

Cost

Tilling includes increased efforts and costs as compared to adding lime and organic matter without tilling. However, minimal soil handling is required as soils generally remain in place, minimizing transportation and disposal costs compared to excavation and soil cover. Long term operation,

maintenance and monitoring (OMM) costs are considered low to moderate and would include monitoring and maintaining BMPs and monitoring plant coverage and soil chemistry.

Screening Results

Tilling is being retained for comparison with other remedial technologies in the FS and for potential use in conjunction with other technologies where implementability may be low. Tilling could potentially be applied at the majority of the site areas containing sufficient equipment access and appropriate terrain slopes or at targeted locations where it is determined that lime and organic matter soil amendments are not warranted.

5.7 Soil Amendments – Ferrihydrite

The use of the soil amendment ferrihydrite as a potential soil remedial technology is being evaluated for use at STSIU as part of a comprehensive remedial alternative. The addition of ferrihydrite to soils containing copper has been observed to bind copper, reduce free Cu^{2+} activity, and total soluble and labile concentrations of copper. High surface area (non-crystalline) hydroxides, such as ferrihydrite, have been demonstrated to be successful at reducing the solubility of copper and other trace metals, due to their high reactivity and effectiveness at removing dissolved organic carbon from solution. The free Cu^{2+} activity reduction is likely due to the higher soil pH that is caused by the introduction of the ferrihydrite amendment.

Although the size of the total soluble and labile pools of copper may be reduced by using heavy additions of high surface area Fe-oxides, such as ferrihydrite, phytotoxicity has been observed to occur in the vegetation present within the soils being treated. The potential for phytotoxicity may be due to increased solubility of accessory toxic elements in the soil or decreased solubility of essential trace elements, leading to poorer plant growth. The soil amendments - ferrihydrite technology is summarized as Technology No. 4c in Table 5-1.

Preliminary Screen

Effectiveness

Overall effectiveness of using ferrihydrite would have to be determined by conducting a pilot and potentially a bench scale treatability study. Factors that would be evaluated during the treatability studies would include, but would not be limited to, loading rates of the ferrihydrite and potential other amendments such as magnesium oxide or lime, to buffer the resulting pH levels, mixing methodologies and equipment, impacts of amended soils on bird ingestion and bioavailability to plants, and impacts of increased iron in soils on human health and ecological receptors.

Implementability

Implementability is generally considered to be feasible at the site where equipment and materials can access the areas requiring treatment. The most efficient mixing methodologies (in-situ or ex-situ) and equipment would have to be tested and determined during a pilot treatability study.

Cost

Factors such as the amendment loading rates and mixing methodologies that would be determined during a pilot treatability study, could greatly impact the costs for this technology. In addition, the market cost of amendments could cause costs to fluctuate for this technology. However, overall costs are considered to be comparable to the amendments being tested as part of the Amendment Study.

Screening Result

This remedial technology will be retained for further evaluation as part of a comprehensive remedial alternative in the FS Report. However, pilot and/or bench scale treatability studies are not being proposed to be conducted at this time. The need for ferrihydrite treatability studies will be further examined if the ongoing Amendment Study results demonstrate that alternate amendments would be beneficial in testing.

5.8 Soil Amendments – Chelating Agents

The application of chelating agents as a potential soil remedial technology is being evaluated for use at STSIU as part of a comprehensive remedial alternative. Specifically, chelating agents are being evaluated for use in the following soil remedial technologies:

- Phytoextraction;
- Soil Washing (Ex-Situ); and
- Soil Washing (In-Situ).

Chelating agents are compounds that are added to the soil to either assist in increasing the uptake of the contaminant (i.e., copper) into plants for the phytoextraction process or for removing a metal from soils as part of a soil washing technique. The use of chelating agents in the phytoextraction and soil washing processes are discussed in detail below and are summarized as Technologies Nos. 4d1, 4d2, and 4d3 in Table 5-1.

5.8.1 Soil Washing (Ex-Situ)

Ex-situ soil washing is a soil remedial technique consisting of removing and concentrating contaminants from bulk soil using separation methodologies. Soil washing can be applied to soils containing heavy metals. The resulting concentrated soil containing the contaminants must be characterized for further treatment and/or offsite disposition. The “clean” portion of the separated soil is also characterized to determine if it meets the criteria for on-site reuse to be returned to the excavations or if it requires further treatment and/or offsite disposition.

The soil washing treatment process begins with excavating, consolidating, and then mechanically sifting the contaminated soils to remove larger diameter objects such as rocks, vegetative root balls, and/or debris. The sifted soil is subsequently placed into a scrubbing unit where water and in some cases a specified detergent are added to the contaminated soil. The specified detergent generally includes either an acid or chelating agent to assist in removing the metals from the soil into the wash solution. Chelating agents assist in making the metals adhered to the soils more water soluble and are considered less environmentally disruptive as compared to the use of acid in the soil washing detergent solution.

The soil mixture is then “washed” and separated by particle size within the scrubbing unit by passing through sieves, mixing blades, and water sprays. The contaminants tend to be removed in the wash water/detergent mixture or adhere to the smaller diameter soil particles such as clay and silt. The larger soil particles such as sand and gravel settle to the bottom of the scrubbing unit. After the soil is washed, the separated components (e.g., water, clay/silt, and sand/gravel) are analyzed for COCs. Depending on the results of the analytical data, the clay and silt portions and the sand and gravel portions may be washed again using a clean water mixture in the scrubbing unit for further separation or they may be characterized for further treatment, offsite disposal, or reuse onsite.

The design of the soil washing process, including the size of scrubber unit, type of soil washing detergent, and soil handling requirements, will be determined via a pilot treatability study and during the remedial design.

Preliminary Screen

Effectiveness

A soil washing system that includes suspending or dissolving soil in a wash solution, particle-size separation, and/or gravity separation could be effective at treating contaminated soils. Because there is one primary soil constituent to be treated (copper), one washing solution could be formulated for treatment, simplifying the soil washing process and design. A pilot treatability study would be required to determine the effectiveness of ex-situ soil washing.

Implementability

A pilot treatability study would need to be conducted to determine the implementability of this technology. Multiple washing steps such as mechanically sifting, suspending soil in a wash solution, particle-size separation, gravity size separation and/or scrubbing would be required because of expected heterogeneity in excavated soil and debris. Treated soil may contain hazardous levels of the washing solvent and require additional soil washing treatment. The aqueous stream generated from the washing treatment would have to be separated from the cleaned soils for offsite disposal prior to returning cleaned soils to the site for reuse. In addition, this technology also requires the same if not an increased level of soil handling when compared to excavation. Site accessibility issues, including the remote nature of the site and the incongruous nature of areas needing treatment, will make soil washing less implementable or potentially infeasible for certain portions of the site.

Cost

Costs for soil washing are considered moderate to high. Soil washing is labor intensive and includes soil excavation, soil washing process, and soil replacement. Additional costs for disposal of soil wash solvent and potentially contaminated resulting soil fines (silts and clays) would increase costs. Cost savings would be recognized through having reduced offsite disposal and less need for imported backfill as compared to excavation.

Screening Result

Although the cost of soil washing may be moderately lower than excavation, the uncertainty of this technology and the access limitations of water and equipment to certain areas of the STSIU does not make it a viable remedial technology. Soil washing is not being retained as a remedial technology for consideration as part of the comprehensive remedial alternative for further evaluation in the FS Report.

5.8.2 Soil Washing (In-Situ)

In-situ soil washing consists of introducing a chelating agent into the soil. The chelating agent assists in mobilizing the contaminant within the soil column and allows it to become more soluble in the groundwater. The groundwater, containing the site contaminant, is then extracted with a groundwater extraction system for treatment and/or disposal.

Preliminary Screen

Effectiveness

In-situ soil washing is potentially effective at removing site contaminants from soils. A pilot treatability study would be required to determine the effectiveness of the technology, including the

appropriate chelating agent to use; extent of in-situ soil mixing required, and groundwater extraction system configuration.

Implementability

A pilot treatability study would be required to determine the implementability of this technology. However, due to the large areas requiring soil treatment and the lack of a current infrastructure to support an extensive groundwater treatment extraction system, this technology is considered to have low implementability. In addition, site accessibility issues make in-situ soil washing less implementable if it is difficult or infeasible to access certain portions of the STSIU requiring treatment.

Cost

In-situ soil washing is labor intensive and would require mixing a chelating agent into contaminated soils, installation of a groundwater extraction system, groundwater extraction, and groundwater treatment and/or disposal. Potential cost savings would be recognized by not having to remove or import and replace site soils. However, costs for construction and future O&M activities (groundwater extraction, treatment, and disposal) of in-situ soil washing are considered very high and outweigh the potential cost savings.

Screening Result

Due to the lack of infrastructure required for the groundwater extraction system, the high costs, and the uncertainty in the effectiveness, in-situ soil washing is not considered a viable remedial technology. In addition, site accessibility issues, including the remoteness of the site and incongruous nature of areas needing treatment, will make soil washing less implementable or potentially infeasible for certain portions of STSIU. Therefore, in-situ soil washing is not being retained as a remedial technology for consideration as part of the comprehensive remedial alternative for further evaluation in the FS Report.

5.8.3 Phytoextraction

Phytoextraction is the process of plants taking up contaminants (i.e., copper) located in the soils via the plant root system. Once the metals have been transferred through the root system, the contaminants are subsequently transferred and accumulated into the aboveground portions of the plant tissue. Once the phytoaccumulation (contaminants transferred to the above ground plant tissue) has occurred, the contaminants are removed from the site by harvesting the plants. An additional phytoextraction technology consists of the contaminant accumulation occurring just in the root system, resulting in the need to harvest the entire plant (including the roots) to remove the contaminants from the site.

Chelating agents can be applied to the soil to increase the uptake and accumulation of the contaminant in the plant. When chelating agents are applied to the soils as part of the phytoextraction process, the technology is considered to be “induced” or chemically enhanced as compared to “natural” phytoextraction where chelating agents or other chemicals are not utilized. Depending on the chelating agent chosen, it typically increases solubility of the metal so it can more readily be taken up from the soil to the plant root system, consequently increasing the rate of phytoextraction.

The plant species selected for phytoextraction must be able to tolerate the site contamination (i.e., copper), must be fast growing, have a high biomass, and easily be harvested.

Preliminary Screen

Effectiveness

Phytoextraction would not be protective of groundfeeding birds, due to the elevated concentrations of copper that would be present in the seeds and vegetation. In addition, phytoextraction would have a significantly increased duration of remedial treatment as compared to other technologies such as soil excavation and soil amending. LDRs would be required for an increased duration of time, effectively limiting future re-use of the site. Because of the risk to SGFBs, increased time for phytoextraction to effectively remediate the site, and the extended LDRs, this technology is considered to have low effectiveness.

Implementability

Phytoextraction has not been tested at the site so currently is considered low for implementability. A pilot treatability study would need to be conducted to determine if the site is capable of supporting the vegetative species that would be effective at removing contaminants from the soil. If a pilot study found that some plant species were successful at the site, other factors such as the success of establishing the required vegetative cover and the erosion and sedimentation of newly revegetated areas, would reduce the implementability of this technology.

Cost

Phytoextraction is a significantly less invasive remedial technology and would require less initial costs related to construction and material handling efforts as compared to soil excavation, soil amendment, and soil washing. However, there would be an increase in future O&M costs and efforts due to extended duration of harvesting plants, replanting requirements, and disposal of contaminated plants. In addition, there would be an increase in BMPs required to minimize erosion and sedimentation due to the frequent harvesting and replanting requirements.

Screening Result

Although phytoextraction costs significantly less during the initial phase of treatment and is less invasive as compared to other soil remedial technologies, the uncertainty of this technology being effective in the natural environment, the potential of groundfeeding birds consuming impacted vegetation and seeds, and the significantly increased treatment duration, does not make it a viable option. Phytoextraction is not being retained as a remedial technology for consideration as part of the comprehensive remedial alternative for further evaluation in the FS Report.

5.9 Containment – Soil Cover

The use of a soil cover is being considered as a potential remedial technology at the site to contain the impacted soils and prevent exposure of site contaminants to potential site receptors. As part of this remedial technology, a soil cover would be placed over existing soils with site contaminant levels above the Pre-FS RAC values. In addition, areas of the site that currently consist of soils intermixed with exposed bedrock but have been determined to historically contain fully established soil and vegetative covers will be considered for a soil cover.

The purpose of the soil cover is to place imported, approved soils upon impacted soils or exposed bedrock areas to provide a layer of clean soil that would provide protection of SGFBs and would promote growth of local, naturally occurring vegetation. Clean, approved soil cover material would be spread, graded, and compacted to promote positive drainage. The minimum thickness and type of soil, including percentage of organic matter, to be used for the soil cover would be selected during the remedial design.

Engineering controls such as BMPs and vegetative cover would be used in conjunction with the placement of the soil to establish vegetative cover, minimize erosional scenarios, and maintain the integrity and minimal thickness of the soil cover. Long term OMM activities would be conducted after the final soil cover construction to verify that the integrity of the soil cover is being maintained. The specific BMPs, vegetative cover, and long term OMM activities would be determined during the remedial design. The containment – soil cover technology is summarized as Technology No. 5a in Table 5-1.

Preliminary Screen

Effectiveness

An engineered soil cover with appropriate thickness would be effective at protecting wildlife receptors from the underlying contamination. However, because contamination will still be present onsite above Pre-FS RAC values, institutional controls could be used in conjunction with the soil cover to ensure that future intrusive work or construction is properly conducted to protect human health and the environment. In addition, sediment and erosion control measures would be critical to the effectiveness of the soil cover to verify that the cover is maintaining its integrity and ability

to provide protection. A soil cover with associated institutional controls is considered an effective remedial technology for the site.

Implementability

Construction of a soil cover is generally considered to be a technically implementable technology for protecting human health and the environment at the site. However, factors that may reduce the implementability include equipment and personnel accessibility to some portions of the site and generation of fugitive dust emissions throughout the duration of heavy construction and material transport activities.

Cost

The costs associated with the soil cover are considered low to moderate as compared to soil excavation and soil amending technologies. Soil cover costs would include an analysis of cover borrow sources and reclamation of borrow sources, followed by installation of BMPs, and long term OMM costs.

Screening Result

Installation of a soil cover is considered to be a viable, cost-effective, and easily implementable remedial technology and will be retained as a remedial technology to be considered a part of the comprehensive remedial alternative for further evaluation in the FS Report.

5.10 Containment – Impermeable Cover

This remedial technology consists of placing an impermeable cover over targeted areas with soil contaminant levels above the RAC. This technology would include preparing the ground surface and site grades to accommodate the installation of the impermeable cover layer. Ground surface preparation activities would include clearing and grubbing existing vegetation, and smoothing and compaction of the ground surface using general construction equipment such as excavators, graders, and rollers. Once proper ground surface conditions have been met (i.e., site grade and subgrade compaction), the impermeable cover would be installed. Details of the impermeable cover, including subgrade preparation requirements, subbase layers, and final impermeable cover material and thickness would be determined during the remedial design. The containment – impermeable cover technology is summarized as Technology No. 5b in Table 5-1.

Preliminary Screening

Effectiveness

An impermeable cover would be highly effective at reducing, if not eliminating, exposure of site receptors to impacted soils contained beneath the cover. However, an impermeable cover, such as

an asphalt or concrete surface, would eliminate the existing vegetative landscape and would prevent future vegetative growth and potential for future grazing. In addition, an impermeable cover would prevent surface water infiltration and would significantly alter stormwater run-off patterns. Because site contaminants will remain in place beneath the cover, the effectiveness of the site remedy would depend on the integrity of the cover, resulting in an indefinite amount of OMM activities required.

Implementability

Installation is considered implementable in the areas of the site that are generally flat and that are accessible to construction equipment and materials. These areas would thus exclude areas that are too steep and/or have highly variable topography. This technology is not considered implementable on a large scale, but is considered potentially implementable at targeted areas where surface water infiltration and future vegetative growth is not required.

Cost

Costs of this technology are considered moderate and include ground surface preparation and grading, and installation of the impermeable cover and any required sub base materials. Long term OMM costs are considered moderate and would include verifying that the cover is maintained over time and making repairs, as warranted.

Screening Result

Because it is not practical to implement this technology on a large scale and due to the impacts of surface water infiltration and stormwater run-off, and limitations on future vegetated growth and grazing, an impermeable cover is not considered a viable remedial technology to be retained for further evaluation in the FS Report.

5.11 Surface Soil Controls – Phytostabilization

The purpose of surface soil controls is to further stabilize the surface soils to prevent or greatly reduce airborne dispersion of soils and provide overall erosion control. Phytostabilization is considered a remedial technology that would provide increased surface soil controls. Phytostabilization consists of vegetating the ground surface with plant species that are targeted at increasing long term soil stabilization as compared to existing vegetative conditions and/or other revegetation options that are not focused specifically on soil stabilization. The seed and plant species, planting locations and density, thinning requirements, and OMM activities would be determined during the remedial design. The surface soil controls - phytostabilization technology is summarized as Technology No. 6 in Table 5-1.

Preliminary Screening

Effectiveness

This remedial technology is considered to be potentially effective at providing increased soil stabilization and reducing transport of surface soils (and potential site contaminants). Plant species that are considered to provide increased soil stabilization, be naturally occurring and/or that have the ability to thrive in the environment at the site would have to be identified in a pilot study and/or preliminary design phase to determine effectiveness. Although this technology would potentially be effective at increasing the stabilization of impacted soils, the technology used alone would not be effective at reducing site contaminant levels in the soils and vegetation. Phytostabilization could more effectively be used in conjunction with another remedial technology that reduces or removes contaminants.

Implementability

Assuming that effective phytostabilization species can be identified for the site, this technology is considered to be generally implementable at most locations at the site. Phytostabilization may not be implementable in areas of the site where there is not a sufficient amount of surface soil coverage, where adequate groundwater is not present, and/or at areas that are inaccessible to equipment and materials.

Cost

Costs include the costs associated with the seeds and plants, site preparation, planting, and OMM. OMM is considered moderate the first several years until vegetation is considered to be established and then less thereafter. Because phytostabilization must be used in conjunction with another remedial technology that reduces site contaminants in the soil, it is not directly comparable to other remedial technologies. However, phytostabilization is considered to have equivalent costs as other revegetation options that are not focused on stabilization.

Screening Result

Although phytostabilization is not considered a standalone remedial technology that is effective at reducing site contaminants in the soils, this remedial technology will be retained for evaluation in conjunction with another technology that is focused on reducing or eliminating contaminants present in the site soils.

5.12 Phytoremediation

Phytoremediation consists of planting vegetation (trees and/or plants) that can uptake the contaminants located in the soil and subsequently remediate the soils. Trees and/or plants remove the site contaminants when the roots take in water and nutrients from the surrounding impacted

soils. Metals are stored in the roots, stems, or leaves of the vegetation, effectively removing them from the soil. Activities that are associated with the implementation of phytoremediation include selection of the proper tree and plant species, site preparation (potentially clearing and grubbing existing vegetation), planting, and OMM to ensure that the trees and plants are being established. The phytoremediation technology is summarized as Technology No. 7 in Table 5-1.

Preliminary Screening

Effectiveness

Phytoremediation is potentially effective at removing site contaminants through use of natural plant processes. A preliminary remedial design evaluation would be required to determine the effectiveness of contaminant removal from the soils and the most appropriate tree and/or plant species for the naturally occurring environment at the site. Contaminant reduction would take several years to achieve and would not immediately reduce potential exposure of contaminants to site receptors. The effectiveness depends not only on the ability of the tree and/or plant to uptake and break down the contaminant, but also on the condition of the tree or plant. Therefore, OMM activities to care for the trees and/or plants are considered to be critical until they are well established.

Implementability

Assuming that species of trees and plants for phytoremediation can be identified to thrive in the naturally occurring environment and that can uptake the site contaminants, this technology is considered to be generally implementable at most areas of the site that are accessible to equipment and materials. There may be certain areas of the site that may not support the phytoremediation species due to slopes, percent of soil coverage, access to groundwater, and soil conditions.

Cost

Costs include the costs associated with the trees and plants, site preparation, planting, and OMM. OMM costs are considered to be high the first several years until the vegetation is well established. Once the vegetation has been well established, OMM efforts and costs would be greatly reduced. Overall costs of phytoremediation are considered moderate to high as compared to other remedial technologies.

Screening Result

Due to the extended time period it would initially take to reduce site contaminants from the soils and the fact that the site remedy effectiveness is directly dependent on the success of the trees and plants, phytoremediation is not being retained for further evaluation in the FS Report.

5.13 Electrokinetic Remediation

Electrokinetic remediation is being evaluated as part of this FS Work Plan for use at the site as part of the comprehensive remedial alternative. Electrokinetics is based on the principle that when direct current (DC) is passed through contaminated soil, certain (negatively charged) types of contaminants will migrate through the soil pore water to a place where they can be removed. This alternative uses electrode assemblies that are installed in the ground in a square array and connected to a DC voltage power supply. Each electrode assembly contains water, a pump, an electrode, and various controllers and sensors. The outer casing of the electrodes is made of porous ceramic through which the electrical current and contaminants pass. A vacuum is applied to the casings which keeps the water inside the assembly from flowing out and saturating adjacent soils. These electrode assemblies are placed in the desired treatment zone with the ceramic casing at the treatment depth. When the DC power supply is activated, a current passes through the soil. As the electric current is applied to the soil between the electrodes, water flows by electroosmosis in the soil pores usually toward the cathode. When the contaminated water reaches the cathode it is pumped to the surface by circulating water within the ceramic casing.

Electrokinetic remediation has the potential to provide remediation of copper contamination without physically removing any soil. The lack of physical soil removal allows for remediation without impacting the surface vegetation at the cost of increasing acidity in the surface soil. This increase in acidity would compound the already low overall pH in Chino soils east of the historic smelter. The electrokinetic technology is summarized as Technology No. 8 in Table 5-1.

Preliminary Screen

Effectiveness

Overall effectiveness of using electrokinetic remediation would need to be determined by conducting a pilot and potentially a bench scale treatability study. Factors that would be evaluated during the treatability studies would include, but would not be limited to, voltage rates, effectiveness in soils with low moisture content, and the increased acidity to the treated soil.

Although the amount of the total copper may be reduced by using electrokinetics in small areas this technology may not be effective given the large number of acres potentially requiring remedial action at Chino. There are also limitations with electrokinetic remediation in soils with less than 10% moisture, which is common in surface soils at Chino.

Implementability

Electrokinetic remediation has not been tested at the site, so currently is considered low for implementability. Currently, Chino lacks the infrastructure to deliver and remove the water necessary for this technology to work in an arid environment. A pilot treatability study would need

to be conducted to determine if the low soil moisture content in the soil would support the removal of copper and if the increased soil acidity would impact vegetative species.

Cost

The cost associated with electrokinetic remediation is assumed to be moderate to high. Factors such as the spacing and number of electrodes would be determined during a pilot treatability study, could greatly impact the costs for this technology. Therefore, without the results of a pilot study the overall cost of implementation cannot be determined.

Screening Result

It is assumed that it is not practical to implement this remedial technology over large scale area, and therefore this technology will not be retained for further evaluation in the FS Report. Even on a small scale, the potential decreased soil pH and difficulties implementing this alternative in areas with low soil moisture are considered significant enough that this alternative will not be retained for evaluation in the FS Report.

5.14 Summary and Identification of Data Needs

The following soil remedial technologies were evaluated in the preliminary screen:

- No Action;
- Monitoring;
- Excavation and Reuse;
- Excavation and Disposal;
- Soil Amendments – Lime and/or Organic Matter;
- Soil Amendments – Tilling;
- Soil Amendments – Chelating Agents;
- Soil Amendments – Ferrihydrite;
- Containment – Soil Cover;
- Containment – Impermeable Cover;
- Surface Soil Controls – Phytostabilization;

- Phytoremediation; and
- Electrokinetic Remediation.

All of these soil remedial technologies, with the exception of chelating agents as a soil amendment, impermeable soil cover, phytoremediation, and electrokinetic remediation were retained for further evaluation in the FS Report. Besides ongoing sampling activities, there are no additional data needs that need to be considered based on this preliminary screen of remedial alternatives for soil.

6.0 REMEDIAL TECHNOLOGIES: SURFACE WATER

As part of this FS Proposal, a range of potential surface water remedial technologies have been identified and summarized for the drainage areas of the Site. A preliminary screening and evaluation of the potential surface water remedial technologies has been performed to determine which remedial technologies should be retained for consideration as part of the FS, which will include a comprehensive alternatives evaluation for the site. The preliminary screening of each remedial technology is based on USEPA (1988) and includes an evaluation of the effectiveness, implementability, and cost.

Based on the preliminary screening, if the remedial technology is considered viable, it will be retained for consideration as part of the site-wide remedial alternatives analysis. As a result of this review, six technologies were identified and are described in detail below and summarized in Table 6-1. A detailed evaluation will be conducted for each potential remedial alternative in the FS, to be developed following the completion and acceptance by NMED of this FS Proposal. The FS will present a remedial alternative analysis based on the full list of USEPA evaluation criteria as previously discussed in detail in Section 5.0.

The surface water remedial technologies that have been identified for evaluation and preliminary screening in this FS Proposal include the following:

- No Action;
- Monitoring;
- Excavation;
- In-stream Removal of Suspended Sediments;
- Limestone Treatment;
- In-situ Treatment; and
- Sediment and Erosion Control.

A detailed explanation of these surface water remedial technologies and a preliminary screening of each technology are included below.

6.1 No Action

This remedial technology consists of leaving the drainage areas which are known to contain surface water with levels of site contaminants above surface water Pre-FS RAC values, in their current condition without performing any soil, sediment, vegetation, groundwater and/or surface water

removal or treatment. This technology is being retained to serve as a baseline control to compare to other potential surface water remedial technologies. This technology is summarized as Technology No. 1 in Table 6-1.

Preliminary Screening

Effectiveness

Site contaminants will naturally attenuate over the course of time. However, this remedial technology does not provide active mechanisms to reduce the short- and mid-term exposure pathways of contaminants contributing to surface water Pre-FS RAC exceedances. Therefore, this remedial technology has overall low effectiveness in reducing potential risk to site receptors.

Implementability

There are no remedial activities associated with this technology and therefore, this remedial technology is considered highly implementable.

Cost

Costs associated with monitoring for no action are considered low.

Screening Result

No Action is being retained as a baseline control for comparison with other remedial technologies in the FS and for potential use in conjunction with other technologies where implementability may be low.

6.2 Monitoring

This remedial technology consists of leaving the drainage areas which are known to contain surface water with levels of site contaminants above surface water Pre-FS RAC values, in their current condition without performing any soil, sediment, vegetation, groundwater and/or surface water removal or treatment. As part of this technology, a monitoring program would be implemented to observe and document the occurrence of natural attenuation of site contaminants. Monitoring would include collection of qualitative and quantitative samples of site media such as surface water, in-drainage sediments, and/or vegetation. This technology is being retained to serve as a baseline control to compare to other potential surface water remedial technologies. This technology is summarized as Technology No. 2 in Table 6-1.

Preliminary Screening

Effectiveness

Site contaminants will naturally attenuate over the course of time. However, this remedial technology does not provide active mechanisms to reduce the short- and mid-term exposure pathways of contaminants contributing to surface water Pre-FS RAC value exceedances. Therefore, this remedial technology has overall low effectiveness in reducing potential risk to site receptors.

Implementability

Activities associated with this technology include establishing a monitoring program and, therefore, this remedial technology is considered highly implementable.

Cost

Costs for this remedial technology are associated with development and implementation of a monitoring program. Costs will vary slightly on types of monitoring (quantitative and qualitative) and duration of monitoring period selected. Costs associated with monitoring for natural attenuation are considered low.

Screening Result

No Action is being retained as a baseline control for comparison with other remedial technologies in the FS and for potential use in conjunction with other technologies where implementability may be low.

6.3 Excavation

This remedial technology consists of the removal of soils and/or sediments from the specified drainage areas. An ongoing study is being conducted to determine the loading analysis of the contaminants contributing to the surface water impacts (see discussion in Section 4 and Appendix B). The purpose of the study is to determine which environmental media (i.e., drainage area sediments, drainage area soils, groundwater, and/or surface water run-off from the upland area) are contributing to surface water impacts and its' respective loading rate. If this study determines that the soils and sediments located within the specified drainage area boundaries are contributing to the surface water contamination at a significant enough loading rate to require remediation, excavation will be considered a viable remedial technology to consider for the comprehensive remedial alternative. This technology is summarized as Technology No. 3 in Table 6-1.

Excavation Approach

Prior to soil and/or sediment excavation, surface materials such as vegetation, drainage bed boulders, rocks, etc. would be cleared and stockpiled along the perimeters of the work areas. If it is determined that soil and sediment removal is required, the extent of rock and vegetation removal, including removal of root balls and/or protection of larger woody trees to be left in place, would be determined during the remedial design. Removed vegetation may be used to provide ground cover for birds and animals in the area. In addition, depending on the type of vegetation present, vegetation could be reduced in size and chipped for potential use as ground cover throughout the duration of construction to minimize fugitive dust generation or transported offsite for disposal. If determined to be the appropriate size during the remedial design process, boulders and/or rocks may be temporary staged to be reused as final cover material after soil and/or sediment excavation has been completed.

Soil and sediment scraping/removal and transport onsite would be conducted using general heavy construction equipment such as excavators, loaders, and potentially soil vacuum removal equipment. In addition, soil and sediment could be removed using hand removal techniques such as shoveling near sensitive areas such as roads, trees to remain in place, or utilities. Physical site factors, such as depth of soil/sediment to be removed, geotechnical properties of the soil/sediment, extent of vegetation, surface slopes, equipment and personnel accessibility, and availability of areas for materials staging and processing will influence the final selection of construction equipment to be utilized. Removed soils/sediment would be staged at designated areas to be determined during the development of the remedial design. Removed soils would be characterized in accordance with RCRA regulations to determine final offsite disposition requirements.

BMPs can be applied throughout the duration of construction to minimize erosion due to wind, rain, and sedimentation from the work areas. Selected BMPs will be determined during the remedial design process and will vary depending on condition of the work area surroundings (i.e., slopes, presence of bodies of water, roads, etc.).

In areas where removal of soils/sediments and overlying vegetation occurred, the newly exposed surface will generally consist of bedrock and/or soils/sediment with copper levels below surface water Pre-FS RAC values. The excavated areas may be replaced with approved imported soils/sediments, stone, and/or riprap. The type and extent of material restoration, including final elevations, would be determined by the remedial design. The excavated areas would be final graded to accommodate the naturally occurring surface water flow direction of the drainage area.

Preliminary Screen

Effectiveness

Assuming that soils/sediments within the drainage areas are contributing to surface water contamination, excavation is considered to be an effective remedial technology at reducing contaminants in surface water. However, excavation does not serve as a stand-alone remedial

technology if removed soils/sediments must be further processed through disposal offsite or treatment and disposal offsite.

Implementability

Excavation of impacted soils/sediments within the drainage areas is generally considered to be a technically implementable technology. However, factors that reduce the implementability include equipment and personnel accessibility at some portions of the drainage areas, in particular due to sharp slopes and the presence of mature trees, and generation of fugitive emissions throughout the duration of material disturbance, heavy construction, and material transport activities.

Cost

Excavation costs are considered to be high and include equipment use and maintenance, material handling onsite (soil and sediment excavation, staging, and replacement), and material transport and disposal at a RCRA-permitted facility. Additional costs associated with soil/sediment sampling and characterization and soil treatment to meet LDRs may be required prior to disposal.

Screening Results

Excavation of sediments seems to be an effective and technically implementable way of removing contaminated sediments from surface water although the costs associated with the excavation of sediments are considered to be high. Therefore, excavation of sediments is being retained for further evaluation as part of a comprehensive remedial alternative in the FS.

6.4 In Stream Removal of Suspended Sediments

This remedial technology consists of in-stream removal of suspended sediments via construction of settling basins within the stream drainage area pathway. The contaminants are adhered to the suspended sediments located within the surface water, subsequently contributing to the exceedences of the surface water Pre-FS RAC values. Removal of the suspended sediments containing the contaminants will result in lowering the contaminant concentrations in the surface water.

The objective of the settling basins is to create zones within the naturally occurring drainage area where the velocity of surface water is sufficiently lowered to allow for the suspended sediments to descend to the bottom of the pool and accumulate. The velocity of the settling pools would be low enough to allow for the sediments that have settled to the bottom of the pool to remain in place until they are removed by mechanical methods such as an excavator.

Multiple settling basins would be constructed at specified locations along the drainage area to capture sediments at different points along the surface water drainage pathway. The location, size, and materials of the settling basins would be determined during the remedial design. The settling

basins would be located in areas that are easily accessible by construction equipment for removal of the accumulated sediments. The frequency of sediment removal from the settling pools will depend on the rate of sediment accumulation and would be determined during the remedial design. This technology is summarized as Technology No. 4 in Table 6-1.

Preliminary Screen

Effectiveness

In-stream removal of sediments is generally considered to be an effective method for reducing the quantity of contaminated sediments from the surface water. There are settling basins located near the site which have been shown to be effective in capturing sediments during storm events that create surface water conditions. However, because there would be a limited number of settling basins present, there is a potential for a small quantity of contaminated sediments remaining in the drainage downstream of the settling basins during high flow. During these high flow events, the limited number of settling basins may not slow the velocity of the run-off enough for the sediment to be removed from the water column.

Implementability

This technology is generally considered to be implementable on site. There will be limitations on the location of the settling basins due to equipment accessibility issues and naturally occurring terrain that may not be conducive for a settling basin.

Cost

This technology is considered to be of moderate cost when compared to other surface water treatment technologies.

Screening Results

In-stream removal of sediments seems to be an effective, technically implementable, and cost-effective way of removing contaminated sediments from surface water. Therefore, in-stream removal of sediments is being retained for further evaluation as part of a comprehensive remedial alternative in the FS.

6.5 Limestone Treatment

This ex-situ remedial technology consists of the installation of limestone features within the surface water drainage area to passively treat surface water with contaminant levels above the Pre-FS RAC levels. Contaminants which adhere to the suspended sediments in surface water contribute to lowering the pH of the water which creates a more acidic environment when compared to naturally occurring surface water in the region that do not contain the contaminants. Due to the naturally occurring alkaline conditions of the limestone, as the acidic surface water comes in contact with the

installed limestone features, a chemical reaction occurs between the surface water and the calcium carbonate of the limestone resulting in partial neutralization of the surface water. Once the pH has risen and the surface water becomes less acidic, the contaminants become less bioavailable to the surrounding environment.

Limestone features would require installation at multiple locations along the surface water drainage areas. The multiple locations of the limestone features would provide increased treatment of the surface water as it progresses down the drainage area. The limestone features installation may consist of the construction of a waterfall using limestone masses to increase surface water contact of the water with the limestone. In addition, limestone may be installed as armoring and/or chips. The final design and location of the limestone features would be determined during the remedial design. This technology is summarized as Technology No. 5 in Table 6-1.

Preliminary Screen

Effectiveness

For limestone treatment to be effective, the majority of the surface water must come in contact with the alkaline limestone. This technology is considered to be effective as long as the surface water makes contact with the limestone feature. For surface water that contacts the limestone, the pH of the surface water is lowered, subsequently lowering the bioavailability of the metal (copper) to the surrounding environment.

Implementability

This technology is generally considered to be implementable on site. There are limitations for the location of the limestone features due to equipment accessibility issues and naturally occurring terrain that may not be conducive for the construction of a limestone feature.

Cost

The technology is considered to be a moderate to high cost for treatment of surface waters when compared to in-stream removal of sediments and/or excavation.

Screening Results

Limestone treatment is an effective and technically implementable way of removing contaminated sediments from the surface water. Therefore, installation of limestone features is being retained for further evaluation as part of a comprehensive remedial alternative in the FS.

6.6 In-situ Treatment

This in-situ remedial technology consists of the insertion of an alkaline fluid into the active channel and bar sediments in the drainages of the STSIU to treat surface water with contaminant levels above the Pre-FS RAC levels. This technology would sequester metals and reduce the stored acidity in drainage sediments; therefore, reducing the desorption and mobilization of metal constituents to surface water. Once the pH has risen and the surface water becomes less acidic, the contaminants become less bioavailable to the surrounding environment.

In-situ treatment would need to be evaluated using a pilot study to determine the effectiveness of this technology on the STSIU sediments. This technology would only be an effective remedial technology if the majority of metals loading for the STSIU drainages are related to constituents in legacy sediments. If in-situ treatment is determined to be an effective remedial technology, however, this technology would require extensive infrastructure installation along the drainages for transport and treatment of an alkaline fluid. The final design and location of this infrastructure would be determined during the remedial design. This technology is summarized as Technology No. 6 in Table 6-1.

Preliminary Screen

Effectiveness

For insitu-treatment to be effective, the majority of the metals loading to surface water must be a result of the legacy sediments and the alkaline liquid must come in contact with all contaminated sediments that may leach to STSIU surface water. This technology is considered to be effective as long as the alkaline liquid is applied adequately through-out the contaminated drainage. For the drainages that are treated, there would be less metals leaching and pH depression of the surface water.

Implementability

This technology is considered to have very low implementability in the STSIU. There are large infrastructure requirements to make this in-situ technology effective and accessibility issues and naturally occurring terrain may not be conducive for this construction.

Cost

The technology is considered to be a high cost for treatment of surface waters when compared to in-stream removal of sediments and/or excavation. The majority of this cost is associated with the infrastructure needed to transport and treat the washing fluid, but the operation and maintenance cost would also be high relative to other remedial technologies.

Screening Results

In-situ treatment may be effective and technically implementable way of neutralizing contaminated sediments prior to leaching to surface water but due to the low implementability and high cost this technology is not being retained for further evaluation as part of a comprehensive remedial alternative in the FS.

6.7 Sediment and Erosion Control

If the ongoing Loading Analysis Study determines that stormwater run-off originating from the upland areas of the site is contributing to surface water impacts within the drainage areas, a comprehensive sediment and erosion control system could be constructed to minimize impacts from entering the drainage areas. The sediment and erosion control system would be considered a permanent remedial technology that would reduce contaminants from entering the surface water located within the drainage area systems.

The sediment and erosion control system would consist of adjusting surrounding grade elevations where necessary and installing various types of BMPs to redirect upland run-off away from the surface water drainage areas and allow it to infiltrate directly into the upland soils. Grading adjustments may include, but may not be limited to, construction of swales, drainage ditches, and/or catch ponds to capture stormwater run-off for infiltration and/or redirect stormwater run-off from entering the drainage areas.

Temporary and permanent BMPs may be utilized as part of the sediment and erosion control system. Temporary BMPs may include silt fences, straw bales, and/or erosion control mats to be installed during construction and be maintained for a limited time after construction until vegetation has sufficiently been established. Permanent BMPs may include placement of gravel, stone, and/or riprap to be placed on newly graded areas, as warranted. The erosion and control system, including grading adjustments and BMP details would be determined during the remedial design. This technology is summarized as Technology No. 7 in Table 6-1.

Preliminary Screen

Effectiveness

If stormwater run-off from the upland is found to be contributing contaminants to the surface water, installation of a sediment and erosion control system would be considered effective in reducing the stormwater pathway to the drainage area.

Implementability

Installation of BMPs and grading adjustments are considered to be technically implementable at the site in reducing stormwater run-off from the uplands to the drainage areas.

Cost

Constructing a sediment and erosion control system is considered to be a low to moderate cost technology when compared with excavation, in-stream removal of sediments, and/or limestone treatment. Costs may depend on the extent of grading adjustments and quantity of permanent BMPs required (higher cost items than temporary BMPs) to minimize stormwater from entering the drainage areas and allow for increased infiltration in the upland.

Screening Results

Construction of sediment and erosion control systems near the drainage areas are considered to be effective, technically implementable, and cost effective. Therefore, installation of sediment and erosion control systems is being retained for further evaluation as part of a comprehensive remedial alternative in the FS.

6.8 Summary and Identification of Data Needs

The following surface water remedial technologies were evaluated in the preliminary screen:

- No Action;
- Monitoring;
- Excavation;
- In-stream Removal of Suspended Sediments;
- Limestone Treatment;
- In-situ Treatment; and
- Sediment and Erosion Control.

All of these surface water remedial technologies were retained except in-situ treatment for further evaluation in the FS Report. Besides ongoing sampling activities, there are no additional data needs that need to be considered based on this preliminary screen of remedial alternatives for surface water.

7.0 SCHEDULE

Chino plans to implement the proposed sampling program listed in the Upland Sampling Work Plan (Appendix A) and Sediment Loading Work Plan (Appendix B) during the summer and fall of 2011. Concurrently, work plans for expedited and formal UAAs as well as criteria adjustment will be submitted to the NMED Surface Water Quality Bureau and implemented during the 2011 field season. The results of these sampling efforts, along with the results of the on-going pH Monitoring Study and Amendment Plot Study, will be reported in the FS Report as the end of 2011. Figure 7-1 summarizes the FS schedule.

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TABLES

492



**TABLE 2-1
CHEMICAL-SPECIFIC POTENTIALLY APPLICABLE STANDARDS FOR THE S/TSIU**

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Regulatory Program/Authority | Citation | Medium of Potential Interest | Notes |
|--|--------------------------------------|------------------------------|---|
| Safe Drinking Water Act (SDWA), Federal | 40 CFR 141 Subpart F | Groundwater, Surface Water | Establishes primary drinking standards for public water systems. |
| SDWA, Federal | 40 CFR 143, Subpart B | Groundwater, Surface Water | Establishes secondary non-enforceable health goals for public water systems at levels resulting in no known or anticipated adverse health effects. |
| Clean Air Act, Federal | 40 CFR 50 | Air | Establishes primary and secondary ambient air quality standards. |
| Clean Air Act, Federal | 40 CFR 60 | Air | Establishes (referenced by NMED AQCR 652) performance standards for new sources based on the specific source categories defined in the regulation. |
| Air Quality Control Act, State | 20.2.3 NMAC | Air | Establishes ambient air quality standards. |
| Air Quality Control Act, State | 20.2.78 NMAC | Air | Defines emissions standards for hazardous air pollutants. |
| New Mexico Water Quality Act | 20.6.2.7.VV NMAC | Groundwater, Surface Water | Definition of a toxic pollutant. |
| New Mexico Water Quality Act | 20.6.2.3101 NMAC | Groundwater | Designates groundwater with total dissolved solids $\leq 10,000$ mg/L as potential source of drinking water. |
| New Mexico Water Quality Act | 20.6.4 NMAC | Surface Water | Provides water quality standards for human contact of surface waters. Defines water quality standards for livestock watering. This statute includes an anti-degradation policy, general water quality standards, primary contact standards, and wildlife standards. |
| New Mexico Water Quality Act | 20.6.2.3103(A) NMAC | Groundwater | Establish human health standards for groundwater quality. |
| New Mexico Water Quality Act | 20.6.2.3103(B) NMAC | Groundwater | Establishes additional standards for domestic water supplies. |
| New Mexico Water Quality Act | 20.6.2.3103(C) NMAC | Groundwater | Establishes groundwater quality standards for irrigation use. |
| Resource Conservation and Recovery Act (RCRA), Federal | 40 CFR 261.24 | Soil | Regulates the determination of hazardous wastes by defining the maximum concentrations of listed contaminants as measured using the Toxicity Characteristic Leaching Procedure (TCLP). |
| CERCLA | 40 CFR 300 Title 1, Section 101, 111 | All Media | References the National Oil and Hazardous Substances Contingency Plan. Establishes funding and provisions for cleanup at hazardous waste sites. |

**TABLE 2-2
ACTION-SPECIFIC POTENTIALLY APPLICABLE STANDARDS FOR THE S/TSIU**

**FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL**

| Regulatory Program/Authority | Citation | Medium of Potential Interest | Description |
|---|--|-------------------------------------|--|
| CERCLA | 40 CFR 300 Title 1, Section 101, 111 | All Media | References the National Oil and Hazardous Substances Contingency Plan. Establishes funding and provisions for cleanup at hazardous waste sites. |
| SARA | 42 USC 9601 | All Media | Establishes clean-up standards and response actions, including the ARAR process (i.e. Applicable Standards). |
| Clean Water Act - National Pollution Discharge Elimination System (NPDES) | 40 CFR 122 CFR 125 40 | Surface Water | Requires permits for discharging pollutants from any point source into waters, lists hazardous substances and water-quality parameters, and defines the criteria and standards for issuances of permits, determining compliance, and granting variances. Establishes Best Management Practices (BMPs) to prevent releases of toxic constituents to surface waters. |
| Clean Water Act | 40 CFR 230 CFR 231 40 Sec 404 | Surface Water | Requires permits for discharging dredged or fill materials into the navigable waters, including wetlands or floodplains. Permits (Sec 404) are issued if the state has authorization, otherwise, Nation Wide Permits (NWP) can be issued by the US Army, Corps of Engineers. Applies to all stream modifications, including underground and surface mining activities. |
| Rivers and Harbors Act of 1899 | 33 CFR 320 CFR 330 33 | Surface Water | Regulates disposal/discharge of dredged or fill materials into US waters, including intermittent streams. |
| RCRA | 40 CFR 241 | Soil | Specifies performance requirements for land disposal of wastes. |
| RCRA | 40 CFR 261 | Soil | Defines criteria for identifying and classifying hazardous wastes. |
| RCRA | 40 CFR 262 | Soil | Establishes standards for generators of hazardous wastes, including requirements for waste shipment packaging, labeling, and manifests. Requirements may be applicable if remediation activities are performed at the S/TSIU and waste generated are hazardous. |
| RCRA | 40 CFR 263 | Soil | Establishes standards for transporters of hazardous wastes. |
| RCRA | 40 CFR 264 | Soil | Establishes standards for owner and operators of facilities for the treatment, storage, and disposal of hazardous wastes. |

**TABLE 2-2
ACTION-SPECIFIC POTENTIALLY APPLICABLE STANDARDS FOR THE S/TSIU**

**FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL**

| Regulatory Program/Authority | Citation | Medium of Potential Interest | Description |
|--|--|-------------------------------------|---|
| RCRA | 40 CFR 268 | All Media | Establishes treatment standards for hazardous constituents, identifies wastes that are restricted from land disposal and defines the limited circumstances under which they may be land disposed. |
| Department of Transportation (DOT) Regulations | 49 CFR 173, 178, 179 | Soil | Establishes requirements for packaging and shipment of hazardous waste. |
| CERCLA Off-Site Response Policy | OSWER 9634.11 | All Media | Defines criteria for qualifying an off-site hazardous waste disposal facility. |
| Clean Air Act | 42 USC Sections 7401 et. seq. | Air | Requires formulation of air quality standards and source performance standards. |
| New Mexico Hazardous Waste Act (NMHWA) NMED Hazardous Waste Bureau (HWB) | NMSA 1978, Sections 74-4-1 through 74-4-14 | Hazardous Waste | Regulates treatment, storage, and disposal of hazardous waste to ensure maintenance to the quality of the state's environment. |
| NMHWA, NMED HWB | 20.4.1.200 NMAC | Hazardous Waste | Defines criteria for identifying and classifying hazardous waste. |
| NMHWA, NMED HWB | 20.4.1.300 NMAC | Hazardous Waste | Defines standards applicable to generators of hazardous wastes for packaging, labeling, and manifesting waste for transport. |
| NMHWA, NMED HWB | 20.4.2.400 NMAC | Hazardous Waste | Defines standards applicable to the transportation of hazardous waste. |
| NMHWA, NMED HWB | 20.4.1.900 NMAC | Hazardous Waste | Identifies hazardous wastes which are restricted from land disposal. |
| New Mexico Solid Waste Management Regulations | 20.9.1 NMAC | Solid Waste | Regulates the permitting, design, location, and operation of solid waste disposal facilities. |
| New Mexico Water Quality Act (NMWQA) | NMSA 1978, Sections 74-6-1 through 74-6-17 | Groundwater, Surface Water | Bans non-permitted discharge of any water contaminant. |
| NMWQA | 20 NMAC 6.2, Section 1-201 | Groundwater, Surface Water | Requires that NMED be notified of any discharge which could affect surface water or groundwater quality. |
| NMWQA | 20 NMAC 6.2, Section 3-104 | Groundwater | Discharge plan may be required for any discharge affecting groundwater quality. |

**TABLE 2-2
ACTION-SPECIFIC POTENTIALLY APPLICABLE STANDARDS FOR THE S/TSIU**

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Regulatory Program/Authority | Citation | Medium of Potential Interest | Description |
|---|-------------------------------|------------------------------|---|
| NMWQA | 20 NMAC 6.2, Section 4-103 | Groundwater, Surface Water | Abatement standards and requirements for the vadose zone, groundwater and surface water. |
| Occupational Safety and Health Act (OSHA) | 29 CFR 1910, 1926, 1954 | All Media | These standards establish safety requirements for hazardous waste operations and sets exposure limits of chemicals. |
| RCRA | 42 USC Sections 8901 et. seq. | Hazardous Waste | Regulates treatment, storage, and disposal of hazardous waste and encourages resource conservation and recycling. |

TABLE 2-3
LOCATION-SPECIFIC POTENTIALLY APPLICABLE STANDARDS FOR THE S/TSIU

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Regulatory Program/Authority | Citation | Medium of Potential Interest | Notes |
|--|---------------------------------|------------------------------|--|
| National Historic Preservation Act | 36 CFR 63 | Historic, Archaeological | Establishes procedures for determining a property's eligibility for inclusion in the National Register of Historic Places. |
| National Historic Preservation Act | 36 CFR 800 | Historic, Archaeological | Requires that federal agencies consider the effects of actions on historic properties and archaeological resources. |
| National Historic Preservation Act of 1979 | 36 CFR 296 43 CFR 7 | Historic, Archaeological | Establishes procedures to be followed by federal land managers in providing protection for archaeological resources. |
| Standards and Guidelines for Archaeology and Historic Preservation | 48 CFR 44716 | Archaeological | Provides guidelines for conducting archaeological surveys. |
| American Indian Religious Freedom Act of 1978 | 42 USC 1996 | Cultural | Requires consultation with local tribes if a project could effect ceremonial, religious, or burial sites. |
| American Indian Graves Freedom and Reparation Act | 25 USC 3001 through 25 USC 3013 | Cultural | Requires that project activities cease if Native American graves are discovered. |
| Migratory Bird-Treaty Act | 50 CFR 10, 21 | Wildlife | Prohibits pursuit, hunting, taking, capture, possession, or killing of all migratory birds or their nests or eggs. |
| Bald and Golden Eagle Protection Act | 50 CFR 10, 22 | Wildlife | Prohibits taking or killing of bald and golden eagles. |
| Endangered Species Act of 1973 | 40 CFR 17 and 50 CFR 402 | Plant, Wildlife | Requires that actions do not jeopardize endangered species or adversely modify their critical habitat, and establishes the process for consulting with the US Fish and Wildlife Service. |
| Fish and Wildlife Coordination Act | 40 CFR 6.302g | Surface Water | Requires that federal agencies be consulted prior to modifying any stream so that wildlife will be protected. |
| Endangered Species Act | 16 USC 1531 | Wildlife | Protects endangered species and restricts activities within their habitat. |
| Resource Conservation and Recovery Act (RCRA) | 40 CFR 241.202 | All Media | Establishes standards for siting RCRA solid-waste disposal facilities. |

**TABLE 2-3
LOCATION-SPECIFIC POTENTIALLY APPLICABLE STANDARDS FOR THE S/TSIU**

**FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL**

| Regulatory Program/Authority | Citation | Medium of Potential Interest | Notes |
|--|---|-------------------------------------|--|
| Fish and Wildlife Coordination Act | 40 CFR 6.302 | Rivers | Protects wildlife habitats and prevents the modification of streams or rivers that effect fish or wildlife. |
| Executive Order, 11990 | 40 CFR 6 Appendix A | Wetlands | Protects wetlands and regulates activities conducted in a wetland area in order to minimize potential destruction, loss or degradation of the wetlands. |
| Clean Water Act | 40 CFR 230 33 CFR 320-330 | Wetlands | Prohibits filling of wetlands and prohibits the discharge dredged or filled material to a wetland without a permit. |
| Executive Order, 11988 | 40 CFR 6 Appendix A | Floodplains | Restricts the types of activities that can be conducted within a floodplain to minimize harm and preserve natural values. |
| New Mexico Cultural Properties Act | NMSA 18.6 | Historic, Archaeological | Requires identification of cultural resources, assessment of potential effects, and consultation with the State Historic Preservation Officer. |
| New Mexico Wildlife Conservation Act, and New Mexico Endangered Plant Act | NMSA 17-2-27 through NMSA 17-2-46 | Plant, Wildlife | Establishes the State's authority to conduct an investigation for the purpose of identifying endangered and threatened species and developing (if necessary) an appropriate management plan for ensuring the protection of such species. |
| New Mexico Prehistoric and Historic Sites and Preservation Act | NMSA 1978, Sections 18-8- 1 through 18-8-8 | Historic, Archaeological | Requires identification of historic resources, assessment of potential impacts, and consultation with State Historic Preservation Office. |
| National Environmental Policy Act | 42 USC Section 4331 et. seq. | Ecosystems | Policy to encourage harmony between humans and the environment to minimize environmental damages and support health and welfare. The Act encourages coordination and cooperation between government agencies in planning and conduction of any action that will affect the government. |
| National Environmental Policy Act | 40 CFR Part 6 | Ecosystems | Procedures requiring integration of all applicable federal laws and executive orders into the environment review process mandated under the Act. |

**TABLE 3-1
SUMMARY OF SURFACE SOIL ARSENIC AND IRON RESULTS**

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| | | | | | | | | | | | | | | | | | | | | | | |
|---|------------|-------|----------------------------|----------------------------|----------------------------|----------------------------|-----------------------------|-----------------------------|----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|----------------------------|----------------------------|----------------------------|-----------------------------|----------------------------|-----------------------------|----------------------------|----------------------------|
| Sample Location: Sample Depth (inch): Date Collected: | Pre-FS RAC | Units | S1 0 - 1 11/06/04 | S2 0 - 1 11/06/04 | S3 0 - 1 11/06/04 | S4 0 - 1 11/06/04 | S5 0 - 1 11/06/04 | S6 0 - 1 10/28/04 | S7 0 - 1 10/28/04 | S8 0 - 1 11/06/04 | S9 0 - 1 10/29/04 | S10 0 - 1 11/06/04 | S11 0 - 1 10/27/04 | S12 0 - 1 10/28/04 | S13 0 - 1 10/28/04 | S14 0 - 1 10/29/04 | S15 0 - 1 10/29/04 | S16 0 - 1 11/06/04 | S17 0 - 1 10/27/04 | S18 0 - 1 10/27/04 | S19 0 - 1 10/30/04 | S20 0 - 1 10/27/04 |
| Metals | | | | | | | | | | | | | | | | | | | | | | |
| Arsenic | 27 | mg/kg | 3.70 J | 1.80 J | 3.50 J | 1.60 J | 3.30 J | 3.80 J | 3.20 J | 4.30 J | 5.00 J | 3.00 J | 3.40 J | 2.50 J | 6.40 J | 5.60 J | 6.80 J | 4.50 J | 3.60 J | 3.60 J | 5.00 J | 3.50 J |
| Iron | 100,000 | mg/kg | 13,100 | 9,630 | 15,300 | 45,500 | 9,750 | 19,300 | 18,500 | 21,200 | 16,800 | 13,900 | 17,100 | 17,000 | 21,000 | 19,100 | 24,000 | 17,100 | 20,100 | 16,500 | 19,300 | 18,000 |
| | | | | | | | | | | | | | | | | | | | | | | |
| Location ID: Sample Depth(Inches): Date Collected: | Pre-FS RAC | Units | S21 0 - 1 10/27/04 | S22 0 - 1 10/30/04 | S23 0 - 1 10/28/04 | S24 0 - 1 10/28/04 | S25 0 - 1 10/30/04 | S26 0 - 1 10/28/04 | S27 0 - 1 10/28/04 | S28 0 - 1 10/30/04 | S29 0 - 1 10/31/04 | S30 0 - 1 10/28/04 | S31 0 - 1 10/30/04 | S32 0 - 1 10/29/04 | S33 0 - 1 10/29/04 | S34 0 - 1 10/29/04 | S35 0 - 1 11/07/04 | S36 0 - 1 11/10/04 | S37 0 - 1 11/07/04 | S38 0 - 1 11/07/04 | S39 0 - 1 11/11/04 | S40 0 - 1 11/11/04 |
| Metals | | | | | | | | | | | | | | | | | | | | | | |
| Arsenic | 27 | mg/kg | 3.30 J | 6.30 J | 2.60 J | 2.80 J | 3.40 J | 3.10 J | 2.90 J | 2.90 J | 1.40 J | 1.10 J | 2.50 J | 2.70 J | 2.60 J | 2.80 J | 4.80 J | 4.70 J | 5.10 J | 5.90 J | 6.50 J | 9.40 J |
| Iron | 100,000 | mg/kg | 20,500 | 19,800 | 17,000 | 17,100 | 17,900 | 18,300 | 17,900 | 16,000 | 18,100 | 14,500 | 13,900 | 15,300 | 14,500 | 17,900 | 18,200 | 21,100 | 19,900 | 19,000 | 18,900 | 24,500 |
| | | | | | | | | | | | | | | | | | | | | | | |
| Location ID: Sample Depth(Inches): Date Collected: | Pre-FS RAC | Units | S41 0 - 1 11/07/04 | S42 0 - 1 11/08/04 | S43 0 - 1 11/11/04 | S44 0 - 1 11/11/04 | S45 0 - 1 11/08/04 | S46 0 - 1 11/08/04 | S47 0 - 1 11/11/04 | S48 0 - 1 11/11/04 | S49 0 - 1 11/07/04 | S50 0 - 1 11/08/04 | S51 0 - 1 11/09/04 | S52 0 - 1 11/11/04 | S53 0 - 1 11/07/04 | S54 0 - 1 11/08/04 | S55 0 - 1 11/09/04 | S56 0 - 1 11/09/04 | S57 0 - 1 11/08/04 | S58 0 - 1 11/08/04 | S59 0 - 1 10/30/04 | S60 0 - 1 10/30/04 |
| Metals | | | | | | | | | | | | | | | | | | | | | | |
| Arsenic | 27 | mg/kg | 6.20 UJ | 6.30 J | 3.70 J | 0.980 J | 8.00 J | 8.20 J | 13.3 J | 7.30 J | 10.3 J | 1.80 J | 5.20 J | 3.70 J | 15.1 J | 7.30 J | 4.50 J | 3.10 J | 3.50 J | 3.90 J | 18.9 J | 21.8 J |
| Iron | 100,000 | mg/kg | 33,600 | 25,100 | 12,800 | 7,170 | 57,500 | 39,400 | 34,900 | 21,000 | 41,000 | 13,900 | 25,500 | 14,300 | 45,700 | 34,800 | 24,200 | 18,600 | 34,600 | 32,700 | 62,400 | 58,600 |
| | | | | | | | | | | | | | | | | | | | | | | |
| Location ID: Sample Depth(Inches): Date Collected: | Pre-FS RAC | Units | S61 0 - 1 10/31/04 | S62 0 - 1 10/31/04 | S63 0 - 1 10/31/04 | SS97 0 - 1 07/24/06 | SS98 0 - 1 07/22/06 | SS99 0 - 1 07/11/06 | SS100 0 - 1 07/12/06 | SS101 0 - 1 07/12/06 | SS102 0 - 1 07/12/06 | SS103 0 - 1 07/24/06 | SS104 0 - 1 07/22/06 | SS105 0 - 1 07/20/06 | SS106 0 - 1 07/22/06 | SS107 0 - 1 07/19/06 | SS108 0 - 1 07/17/06 | SS109 0 - 1 07/20/06 | SS110 0 - 1 07/22/06 | SS111 0 - 1 07/19/06 | SS112 0 - 1 07/19/06 | SS113 0 - 1 07/17/06 |
| Metals | | | | | | | | | | | | | | | | | | | | | | |
| Arsenic | 27 | mg/kg | 25.4 J | 16.0 J | 9.40 J | 3.90 | 3.50 | 1.10 | 1.90 | 2.20 | 2.20 | 2.40 | 2.10 | 2.00 | 2.10 | 0.980 | 1.40 | 1.90 | 2.90 | 2.30 | 2.20 | 1.80 |
| Iron | 100,000 | mg/kg | 34,600 | 35,500 | 24,600 | 29,400 | 38,000 | 9,610 | 20,300 | 55,000 | 34,200 | 12,300 | 10,300 | 30,200 | 10,500 | 7,360 J | 32,300 | 23,600 | 24,700 | 12,100 J | 14,500 J | 14,200 |
| | | | | | | | | | | | | | | | | | | | | | | |
| Location ID: Sample Depth(Inches): Date Collected: | Pre-FS RAC | Units | SS114 0 - 1 07/17/06 | SS115 0 - 1 07/23/06 | SS116 0 - 1 07/22/06 | SS117 0 - 1 07/20/06 | SS118S 0 - 1 07/19/06 | SS119S 0 - 1 07/13/06 | SS120 0 - 1 07/17/06 | SS121 0 - 1 07/11/06 | SS122 0 - 1 07/18/06 | SS123 0 - 1 07/13/06 | SS124S 0 - 1 07/19/06 | SS125S 0 - 1 07/19/06 | SS126 0 - 1 07/22/06 | SS127 0 - 1 07/20/06 | SS128 0 - 1 07/20/06 | SS129S 0 - 1 07/19/06 | SS130 0 - 1 07/21/06 | SS131S 0 - 1 07/18/06 | SS132 0 - 1 07/24/06 | SS133 0 - 1 07/22/06 |
| Metals | | | | | | | | | | | | | | | | | | | | | | |
| Arsenic | 27 | mg/kg | 1.80 | 3.10 | 3.60 | 5.40 | 1.60 | 1.70 | 1.80 | 3.20 | 0.760 | 2.00 | 2.70 | 1.30 | 2.00 | 1.90 | 1.80 | 2.10 | 1.50 | 1.80 | 2.90 | 2.50 |
| Iron | 100,000 | mg/kg | 31,800 | 24,200 | 34,400 | 31,100 J | 13,600 J | 22,100 | 35,400 | 21,400 J | 10,600 J | 14,300 | 26,700 J | 12,300 J | 19,000 | 27,700 J | 31,800 J | 26,000 J | 21,200 | 17,500 J | 26,200 | 23,300 |
| | | | | | | | | | | | | | | | | | | | | | | |
| Location ID: Sample Depth(Inches): Date Collected: | Pre-FS RAC | Units | SS134 0 - 1 07/21/06 | SS135 0 - 1 07/21/06 | SS136 0 - 1 07/22/06 | SS137 0 - 1 07/21/06 | SS138 0 - 1 07/23/06 | SS139 0 - 1 07/24/06 | SS140 0 - 1 07/22/06 | SS141 0 - 1 07/23/06 | SS142 0 - 1 07/21/06 | SS143 0 - 1 07/24/06 | SS144 0 - 1 07/22/06 | SS145 0 - 1 07/23/06 | SS146 0 - 1 07/23/06 | SS147 0 - 1 07/22/06 | SS148 0 - 1 07/18/06 | SS149 0 - 1 07/24/06 | SS150 0 - 1 07/24/06 | SS151 0 - 1 07/15/06 | SS152 0 - 1 07/15/06 | SS153 0 - 1 07/15/06 |
| Metals | | | | | | | | | | | | | | | | | | | | | | |
| Arsenic | 27 | mg/kg | 2.20 | 2.10 | 2.30 | 2.30 | 2.40 | 2.70 | 3.20 | 1.90 | 3.20 | 2.20 | 4.20 | 3.40 | 2.70 | 2.00 | 3.80 | 2.70 | 2.60 | 2.30 | 1.20 | 2.50 |
| Iron | 100,000 | mg/kg | 47,200 | 36,400 | 25,200 | 62,000 | 57,200 | 40,500 | 26,600 | 55,600 | 53,500 | 29,200 | 30,800 | 141,000 | 64,300 | 24,700 | 123,000 J | 46,500 | 24,600 | 19,700 | 24,100 | 24,200 |
| | | | | | | | | | | | | | | | | | | | | | | |
| Location ID: Sample Depth(Inches): Date Collected: | Pre-FS RAC | Units | SS154 0 - 1 07/16/06 | SS155 0 - 1 07/16/06 | SS156 0 - 1 07/13/06 | SS157 0 - 1 07/15/06 | SS158 0 - 1 07/16/06 | SS159D 0 - 1 07/16/06 | SS160 0 - 1 07/16/06 | SS161D 0 - 1 07/16/06 | SS162D 0 - 1 07/11/06 | SS163D 0 - 1 07/11/06 | SS164D 0 - 1 07/14/06 | SS165D 0 - 1 07/14/06 | | | | | | | | |
| Metals | | | | | | | | | | | | | | | | | | | | | | |
| Arsenic | 27 | mg/kg | 0.0400 U | 1.80 | 2.10 | 1.70 | 2.50 | 3.4 | 0.95 | 2.2 | 1.9 | 0.92 | 1.9 | 1.8 | | | | | | | | |
| Iron | 100,000 | mg/kg | 24,400 | 23,300 | 28,600 | 20,100 | 20,100 | 30,100 | 18,400 | 18,800 | 16,200 | 12,700 | 9,460 | 10,600 | | | | | | | | |

TABLE 3-2
SURFACE SOIL COPPER RESULTS ADJUSTED TO 0-6"

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Location ID | Depth Start | Depth End | Copper Result mg/kg | Scaling Factor | Adjust Copper mg/kg |
|-------------|-------------|-----------|------------------------|----------------|------------------------|
| | inches | | | | |
| ERA162 | 0 | 1 | 218 | 0.7 | 153 |
| ERA163 | 0 | 1 | 208 | 0.7 | 146 |
| ERA164 | 0 | 1 | 136 | 0.7 | 95 |
| ERA165 | 0 | 1 | 177 | 0.7 | 124 |
| S1 | 0 | 1 | 1240 | 0.7 | 868 |
| S10 | 0 | 1 | 6090 | 0.7 | 4263 |
| S11 | 0 | 1 | 3880 | 0.7 | 2716 |
| S12 | 0 | 1 | 3160 | 0.7 | 2212 |
| S13 | 0 | 1 | 5920 | 0.7 | 4144 |
| S14 | 0 | 1 | 8030 | 0.7 | 5621 |
| S15 | 0 | 1 | 12100 | 0.7 | 8470 |
| S16 | 0 | 1 | 8310 | 0.7 | 5817 |
| S17 | 0 | 1 | 4650 | 0.7 | 3255 |
| S18 | 0 | 1 | 3670 | 0.7 | 2569 |
| S19 | 0 | 1 | 5660 | 0.7 | 3962 |
| S2 | 0 | 1 | 625 | 0.7 | 438 |
| S20 | 0 | 1 | 4240 | 0.7 | 2968 |
| S21 | 0 | 1 | 6670 | 0.7 | 4669 |
| S22 | 0 | 1 | 5210 | 0.7 | 3647 |
| S23 | 0 | 1 | 3030 | 0.7 | 2121 |
| S24 | 0 | 1 | 3910 | 0.7 | 2737 |
| S25 | 0 | 1 | 4630 | 0.7 | 3241 |
| S26 | 0 | 1 | 2600 | 0.7 | 1820 |
| S27 | 0 | 1 | 3150 | 0.7 | 2205 |
| S28 | 0 | 1 | 5840 | 0.7 | 4088 |
| S29 | 0 | 1 | 1690 | 0.7 | 1183 |
| S3 | 0 | 1 | 2110 | 0.7 | 1477 |
| S30 | 0 | 1 | 2350 | 0.7 | 1645 |
| S31 | 0 | 1 | 3120 | 0.7 | 2184 |
| S32 | 0 | 1 | 2440 | 0.7 | 1708 |
| S33 | 0 | 1 | 2570 | 0.7 | 1799 |
| S34 | 0 | 1 | 4340 | 0.7 | 3038 |
| S35 | 0 | 1 | 3270 | 0.7 | 2289 |
| S36 | 0 | 1 | 3970 | 0.7 | 2779 |
| S37 | 0 | 1 | 1900 | 0.7 | 1330 |
| S38 | 0 | 1 | 4280 | 0.7 | 2996 |
| S39 | 0 | 1 | 2470 | 0.7 | 1729 |
| S4 | 0 | 1 | 7990 | 0.7 | 5593 |
| S40 | 0 | 1 | 3610 | 0.7 | 2527 |
| S41 | 0 | 1 | 8170 | 0.7 | 5719 |
| S42 | 0 | 1 | 5780 | 0.7 | 4046 |
| S43 | 0 | 1 | 2230 | 0.7 | 1561 |
| S44 | 0 | 1 | 908 | 0.7 | 636 |
| S45 | 0 | 1 | 8270 | 0.7 | 5789 |
| S46 | 0 | 1 | 9000 | 0.7 | 6300 |
| S47 | 0 | 1 | 7990 | 0.7 | 5593 |
| S48 | 0 | 1 | 2520 | 0.7 | 1764 |
| S49 | 0 | 1 | 5430 | 0.7 | 3801 |
| S5 | 0 | 1 | 1140 | 0.7 | 798 |
| S50 | 0 | 1 | 272 | 0.7 | 190 |
| S51 | 0 | 1 | 3790 | 0.7 | 2653 |
| S52 | 0 | 1 | 1540 | 0.7 | 1078 |

**TABLE 3-2
SURFACE SOIL COPPER RESULTS ADJUSTED TO 0-6"**

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Location ID | Depth Start | Depth End | Copper Result mg/kg | Scaling Factor | Adjust Copper mg/kg |
|-------------|-------------|-----------|------------------------|----------------|------------------------|
| | inches | | | | |
| S53 | 0 | 1 | 7880 | 0.7 | 5516 |
| S54 | 0 | 1 | 2220 | 0.7 | 1554 |
| S55 | 0 | 1 | 1740 | 1.5 | 2610 |
| S56 | 0 | 1 | 1490 | 0.7 | 1043 |
| S57 | 0 | 1 | 1300 | 1.5 | 1950 |
| S58 | 0 | 1 | 1590 | 1.5 | 2385 |
| S59 | 0 | 1 | 14100 | 0.7 | 9870 |
| S6 | 0 | 1 | 3670 | 0.7 | 2569 |
| S60 | 0 | 1 | 18300 | 0.7 | 12810 |
| S61 | 0 | 1 | 30500 | 0.7 | 21350 |
| S62 | 0 | 1 | 20100 | 0.7 | 14070 |
| S63 | 0 | 1 | 10500 | 0.7 | 7350 |
| S7 | 0 | 1 | 4760 | 0.7 | 3332 |
| S8 | 0 | 1 | 6100 | 0.7 | 4270 |
| S9 | 0 | 1 | 4950 | 0.7 | 3465 |
| SS100 | 0 | 1 | 234 | 0.7 | 164 |
| SS101 | 0 | 1 | 206 | 0.7 | 144 |
| SS102 | 0 | 1 | 201 | 0.7 | 141 |
| SS103 | 0 | 1 | 497 | 0.7 | 348 |
| SS104 | 0 | 1 | 407 | 0.7 | 285 |
| SS105 | 0 | 1 | 226 | 0.7 | 158 |
| SS106 | 0 | 1 | 531 | 0.7 | 372 |
| SS107 | 0 | 1 | 194 | 0.7 | 136 |
| SS108 | 0 | 1 | 252 | 0.7 | 176 |
| SS109 | 0 | 1 | 597 | 0.7 | 418 |
| SS110 | 0 | 1 | 692 | 0.7 | 484 |
| SS111 | 0 | 1 | 551 | 0.7 | 386 |
| SS112 | 0 | 1 | 558 | 0.7 | 391 |
| SS113 | 0 | 1 | 209 | 0.7 | 146 |
| SS114 | 0 | 1 | 119 | 0.7 | 83 |
| SS115 | 0 | 1 | 3800 | 0.7 | 2660 |
| SS116 | 0 | 1 | 1460 | 0.7 | 1022 |
| SS117 | 0 | 1 | 4450 | 0.7 | 3115 |
| SS120 | 0 | 1 | 117 | 0.7 | 82 |
| SS121 | 0 | 1 | 896 | 0.7 | 627 |
| SS122 | 0 | 1 | 119 | 0.7 | 83 |
| SS123 | 0 | 1 | 449 | 0.7 | 314 |
| SS127 | 0 | 1 | 1020 | 1.5 | 1530 |
| SS128 | 0 | 1 | 454 | 0.7 | 318 |
| SS130 | 0 | 1 | 227 | 0.7 | 159 |
| SS132 | 0 | 1 | 740 | 0.7 | 518 |
| SS134 | 0 | 1 | 334 | 0.7 | 234 |
| SS135 | 0 | 1 | 325 | 0.7 | 228 |
| SS137 | 0 | 1 | 309 | 0.7 | 216 |
| SS138 | 0 | 1 | 297 | 0.7 | 208 |
| SS139 | 0 | 1 | 696 | 0.7 | 487 |
| SS141 | 0 | 1 | 320 | 0.7 | 224 |
| SS142 | 0 | 1 | 392 | 0.7 | 274 |
| SS143 | 0 | 1 | 738 | 0.7 | 517 |
| SS145 | 0 | 1 | 413 | 0.7 | 289 |
| SS146 | 0 | 1 | 710 | 0.7 | 497 |
| SS148 | 0 | 1 | 632 | 0.7 | 442 |

TABLE 3-2
SURFACE SOIL COPPER RESULTS ADJUSTED TO 0-6"

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Location ID | Depth Start | Depth End | Copper Result mg/kg | Scaling Factor | Adjust Copper mg/kg |
|-------------|-------------|-----------|------------------------|----------------|------------------------|
| | inches | | | | |
| SS149 | 0 | 1 | 628 | 0.7 | 440 |
| SS150 | 0 | 1 | 605 | 0.7 | 424 |
| SS151 | 0 | 1 | 259 | 0.7 | 181 |
| SS152 | 0 | 1 | 237 | 0.7 | 166 |
| SS153 | 0 | 1 | 438 | 0.7 | 307 |
| SS154 | 0 | 1 | 372 | 0.7 | 260 |
| SS155 | 0 | 1 | 387 | 0.7 | 271 |
| SS156 | 0 | 1 | 196 | 0.7 | 137 |
| SS157 | 0 | 1 | 141 | 0.7 | 99 |
| SS158 | 0 | 1 | 247 | 0.7 | 173 |
| SS97 | 0 | 1 | 412 | 0.7 | 288 |
| SS98 | 0 | 1 | 475 | 0.7 | 333 |
| SS99 | 0 | 1 | 93 | 0.7 | 65 |
| T-01 | 0 | 1 | 1330 | 1.5 | 1995 |
| T-03 | 0 | 1 | 554 | 0.7 | 388 |
| T-04 | 0 | 1 | 549 | 1.5 | 824 |
| T-05 | 0 | 1 | 543 | 0.7 | 380 |
| T-08 | 0 | 1 | 647 | 0.7 | 453 |
| T-09 | 0 | 1 | 645 | 0.7 | 452 |
| T-12 | 0 | 1 | 216 | 0.7 | 151 |
| T-15 | 0 | 1 | 773 | 0.7 | 541 |
| U04-1001 | 0 | 1 | 3560 | 0.7 | 2492 |
| U04-1002 | 0 | 1 | 5240 | 0.7 | 3668 |
| U04-1003 | 0 | 1 | 1880 | 1.5 | 2820 |
| U04-1004 | 0 | 1 | 1140 | 0.7 | 798 |
| U04-1007 | 0 | 1 | 845 | 0.7 | 592 |
| U04-1008 | 0 | 1 | 644 | 0.7 | 451 |
| U04-1009 | 0 | 1 | 803 | 0.7 | 562 |
| U04-1010 | 0 | 1 | 1230 | 0.7 | 861 |
| U04-1011 | 0 | 1 | 990 | 0.7 | 693 |
| U04-1012 | 0 | 1 | 309 | 0.7 | 216 |
| U04-1013 | 0 | 1 | 521 | 0.7 | 365 |
| U04-1014 | 0 | 1 | 504 | 0.7 | 353 |
| U04-1015 | 0 | 1 | 330 | 0.7 | 231 |
| U04-1016 | 0 | 1 | 922 | 0.7 | 645 |
| U04-1017 | 0 | 1 | 216 | 0.7 | 151 |
| U04-1018 | 0 | 1 | 175 | 0.7 | 123 |
| U04-1019 | 0 | 1 | 245 | 1.5 | 368 |
| U04-1020 | 0 | 1 | 436 | 1.5 | 654 |
| U04-1021 | 0 | 1 | 280 | 0.7 | 196 |
| U04-1022 | 0 | 1 | 1790 | 0.7 | 1253 |
| U04-1023 | 0 | 1 | 3410 | 0.7 | 2387 |
| U04-1024 | 0 | 1 | 2040 | 0.7 | 1428 |
| U04-1025 | 0 | 1 | 2490 | 0.7 | 1743 |
| U04-1026 | 0 | 1 | 2260 | 0.7 | 1582 |
| U04-1028 | 0 | 1 | 1340 | 0.7 | 938 |
| U04-1029 | 0 | 1 | 372 | 0.7 | 260 |
| U04-1030 | 0 | 1 | 837 | 0.7 | 586 |
| U04-1031 | 0 | 1 | 1740 | 0.7 | 1218 |
| U04-1032 | 0 | 1 | 1040 | 0.7 | 728 |
| U04-1033 | 0 | 1 | 562 | 0.7 | 393 |
| U04-1034 | 0 | 1 | 424 | 0.7 | 297 |

TABLE 3-2
SURFACE SOIL COPPER RESULTS ADJUSTED TO 0-6"

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Location ID | Depth Start inches | Depth End inches | Copper Result mg/kg | Scaling Factor | Adjust Copper mg/kg |
|-------------|-----------------------|---------------------|------------------------|----------------|------------------------|
| U04-1006 | 0 | 1 | 427 | 0.7 | 299 |
| ERA01 | 0 | 6 | 3517 | NA | 3517 |
| ERA02 | 0 | 6 | 860 | NA | 860 |
| ERA03 | 0 | 6 | 625 | NA | 625 |
| ERA04 | 0 | 6 | 486 | NA | 486 |
| ERA05 | 0 | 6 | 238 | NA | 238 |
| ERA06 | 0 | 6 | 622 | NA | 622 |
| ERA07 | 0 | 6 | 758 | NA | 758 |
| ERA08 | 0 | 6 | 643 | NA | 643 |
| ERA09 | 0 | 6 | 291 | NA | 291 |
| ERA10 | 0 | 6 | 197 | NA | 197 |
| ERA11 | 0 | 6 | 277 | NA | 277 |
| ERA12 | 0 | 6 | 215 | NA | 215 |
| ERA13 | 0 | 6 | 186 | NA | 186 |
| ERA14 | 0 | 6 | 129 | NA | 129 |
| ERA15 | 0 | 6 | 529 | NA | 529 |
| ERA159D | 0 | 6 | 809 | NA | 809 |
| ERA16 | 0 | 6 | 77 | NA | 77 |
| ERA160D | 0 | 6 | 34 | NA | 34 |
| ERA161D | 0 | 6 | 556 | NA | 556 |
| ERA17 | 0 | 6 | 57 | NA | 57 |
| ERA18 | 0 | 6 | 73 | NA | 73 |
| ERA19 | 0 | 6 | 62 | NA | 62 |
| ERA20 | 0 | 6 | 45 | NA | 45 |
| ERA21 | 0 | 6 | 48 | NA | 48 |
| ERA22 | 0 | 6 | 1120 | NA | 1120 |
| ERA23 | 0 | 6 | 973 | NA | 973 |
| ERA24 | 0 | 6 | 63 | NA | 63 |
| ERA25 | 0 | 6 | 70 | NA | 70 |
| ERA26 | 0 | 6 | 535 | NA | 535 |
| ERA27 | 0 | 6 | 328 | NA | 328 |
| ERA28 | 0 | 6 | 1060 | NA | 1060 |
| ERA29 | 0 | 6 | 460 | NA | 460 |
| ERA30 | 0 | 6 | 102 | NA | 102 |
| ERA31 | 0 | 6 | 78 | NA | 78 |
| ERA32 | 0 | 6 | 419 | NA | 419 |
| ERA33 | 0 | 6 | 176 | NA | 176 |
| ERA34 | 0 | 6 | 57 | NA | 57 |
| S64 | 0 | 6 | 689 | NA | 689 |
| S65 | 0 | 6 | 660 | NA | 660 |
| S66 | 0 | 6 | 789 | NA | 789 |
| S67 | 0 | 6 | 899 | NA | 899 |
| S68 | 0 | 6 | 846 | NA | 846 |
| S69 | 0 | 6 | 710 | NA | 710 |
| S70 | 0 | 6 | 2280 | NA | 2280 |
| S71 | 0 | 6 | 5350 | NA | 5350 |
| S72 | 0 | 6 | 1160 | NA | 1160 |
| S73 | 0 | 6 | 1290 | NA | 1290 |
| S74 | 0 | 6 | 529 | NA | 529 |
| S75 | 0 | 6 | 940 | NA | 940 |
| S76 | 0 | 6 | 278 | NA | 278 |
| S77 | 0 | 6 | 267 | NA | 267 |

TABLE 3-2
SURFACE SOIL COPPER RESULTS ADJUSTED TO 0-6"

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Location ID | Depth Start | Depth End | Copper Result mg/kg | Scaling Factor | Adjust Copper mg/kg |
|-------------|-------------|-----------|------------------------|----------------|------------------------|
| | inches | | | | |
| S78 | 0 | 6 | 207 | NA | 207 |
| S79 | 0 | 6 | 157 | NA | 157 |
| S80 | 0 | 6 | 1440 | NA | 1440 |
| S81 | 0 | 6 | 875 | NA | 875 |
| S82 | 0 | 6 | 455 | NA | 455 |
| S83 | 0 | 6 | 358 | NA | 358 |
| S84 | 0 | 6 | 362 | NA | 362 |
| S85 | 0 | 6 | 451 | NA | 451 |
| S86 | 0 | 6 | 513 | NA | 513 |
| S87 | 0 | 6 | 309 | NA | 309 |
| S88 | 0 | 6 | 484 | NA | 484 |
| S89 | 0 | 6 | 399 | NA | 399 |
| S90 | 0 | 6 | 255 | NA | 255 |
| S91 | 0 | 6 | 926 | NA | 926 |
| S92 | 0 | 6 | 581 | NA | 581 |
| S93 | 0 | 6 | 308 | NA | 308 |
| S94 | 0 | 6 | 313 | NA | 313 |
| S95 | 0 | 6 | 494 | NA | 494 |
| S96 | 0 | 6 | 237 | NA | 237 |
| SS118D | 0 | 6 | 259 | NA | 259 |
| SS119D | 0 | 6 | 125 | NA | 125 |
| SS124D | 0 | 6 | 523 | NA | 523 |
| SS125D | 0 | 6 | 166 | NA | 166 |
| SS129D | 0 | 6 | 337 | NA | 337 |
| SS131D | 0 | 6 | 444 | NA | 444 |
| FID 0 | 0 | 6 | 329 | NA | 329 |
| FID 1 | 0 | 6 | 143 | NA | 143 |
| FID 2 | 0 | 6 | 405 | NA | 405 |
| FID 3 | 0 | 6 | 236 | NA | 236 |
| FID 4 | 0 | 6 | 599 | NA | 599 |
| FID 6 | 0 | 6 | 182 | NA | 182 |
| FID 7 | 0 | 6 | 242 | NA | 242 |
| FID 08 | 0 | 6 | 430 | NA | 430 |
| FID 10 | 0 | 6 | 1020 | NA | 1020 |
| FID 12 | 0 | 6 | 4260 | NA | 4260 |
| FID 13 | 0 | 6 | 1970 | NA | 1970 |
| FID 15 | 0 | 6 | 1360 | NA | 1360 |
| FID 16 | 0 | 6 | 512 | NA | 512 |
| FID 17 | 0 | 6 | 4680 | NA | 4680 |
| FID 18 | 0 | 6 | 326 | NA | 326 |
| FID 20 | 0 | 6 | 790 | NA | 790 |
| FID 21 | 0 | 6 | 131 | NA | 131 |
| FID 22 | 0 | 6 | 285 | NA | 285 |
| FID 23 | 0 | 6 | 252 | NA | 252 |
| FID 24 | 0 | 6 | 121 | NA | 121 |
| FID 25 | 0 | 6 | 66 | NA | 66 |
| FID 26 | 0 | 6 | 75 | NA | 75 |
| FID 27 | 0 | 6 | 206 | NA | 206 |
| FID 28 | 0 | 6 | 348 | NA | 348 |
| FID 30 | 0 | 6 | 90 | NA | 90 |
| FID 31 | 0 | 6 | 187 | NA | 187 |
| FID 32 | 0 | 6 | 2120 | NA | 2120 |

TABLE 3-2
SURFACE SOIL COPPER RESULTS ADJUSTED TO 0-6"

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Location ID | Depth Start | Depth End | Copper Result mg/kg | Scaling Factor | Adjust Copper mg/kg |
|---------------------------|-------------|-----------|------------------------|----------------|------------------------|
| | inches | | | | |
| FID 33 | 0 | 6 | 308 | NA | 308 |
| FID 34 | 0 | 6 | 209 | NA | 209 |
| FID 35 | 0 | 6 | 210 | NA | 210 |
| FID 37 | 0 | 6 | 805 | NA | 805 |
| FID 39 | 0 | 6 | 414 | NA | 414 |
| FID 43 | 0 | 6 | 486 | NA | 486 |
| FID 101 | 0 | 6 | 285 | NA | 285 |
| FID 102 | 0 | 6 | 287 | NA | 287 |
| FID 103 | 0 | 6 | 317 | NA | 317 |
| FID 104 | 0 | 6 | 454 | NA | 454 |
| FID 105 | 0 | 6 | 1230 | NA | 1230 |
| FID 106 | 0 | 6 | 450 | NA | 450 |
| Reference #1 (West) | 0 | 6 | 1857 | NA | 1857 |
| Reference #2 (North) | 0 | 6 | 672 | NA | 672 |
| Reference #3 (North East) | 0 | 6 | 2457 | NA | 2457 |
| Reference #4 (East) | 0 | 6 | 1418 | NA | 1418 |
| STS-SS-2010-016 | 0 | 6 | 1120 | NA | 1120 |
| STS-SS-2010-017 | 0 | 6 | 2060 | NA | 2060 |
| STS-SS-2010-018 | 0 | 6 | 1100 | NA | 1100 |
| West-01 | 0 | 6 | 805 | NA | 805 |
| West Ref-01 | 0 | 6 | 873 | NA | 873 |
| North Ref-01 | 0 | 6 | 1012 | NA | 1012 |
| East Ref-01 | 0 | 6 | 977 | NA | 977 |
| North East Ref-01 | 0 | 6 | 3085 | NA | 3085 |

Notes:

mg/kg = milligram per kilogram

Adjusted value only applies to 0-1" samples

TABLE 3-3
STSIU SOIL pCu VALUES

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Location | Copper mg/kg | pH SU | pCu (calculated¹) |
|---------------------|-------------------------|------------------|---|
| FID 0 | 329 | 7.12 | 7.30 |
| FID 1 | 143 | 7.02 | 8.16 |
| FID 2 | 405 | 6.75 | 6.71 |
| FID 3 | 236 | 7.96 | 8.46 |
| FID 4 | 599 | 7.42 | 6.89 |
| FID 6 | 182 | 6.60 | 7.49 |
| FID 7 | 242 | 5.86 | 5.65 |
| FID 8 | 430 | 7.00 | 6.83 |
| FID 10 | 1020 | 5.26 | 3.63 |
| FID 12 | 4260 | 7.32 | 4.54 |
| FID 13 | 1970 | 7.14 | 5.26 |
| FID 15 | 1360 | 5.62 | 4.18 |
| FID 16 | 512 | 5.56 | 3.42 |
| FID 17 | 4680 | 5.95 | 3.02 |
| FID 18 | 326 | 4.47 | 4.45 |
| FID 20 | 790 | 5.98 | 5.23 |
| FID 21 | 131 | 7.34 | 8.56 |
| FID 22 | 285 | 7.20 | 7.20 |
| FID 23 | 252 | 4.88 | 5.79 |
| FID 24 | 121 | 8.05 | 9.31 |
| FID 25 | 66 | 8.17 | 10.12 |
| FID 26 | 75 | 8.02 | 9.83 |
| FID 27 | 206 | 7.11 | 7.83 |
| FID 28 | 348 | 8.01 | 8.11 |
| FID 30 | 90 | 8.11 | 9.70 |
| FID 31 | 187 | 6.57 | 7.43 |
| FID 32 | 2120 | 6.24 | 4.34 |
| FID 33 | 308 | 6.61 | 6.89 |
| FID 34 | 209 | 7.38 | 8.06 |
| FID 35 | 210 | 7.66 | 8.31 |
| FID 37 | 805 | 5.23 | 4.51 |
| FID 39 | 414 | 7.14 | 7.05 |
| FID 43 | 486 | 4.37 | 4.34 |
| FID 101 | 285 | 4.78 | 5.32 |
| FID 102 | 287 | 4.64 | 5.20 |
| FID 103 | 317 | 4.84 | 5.25 |
| FID 104 | 454 | 4.07 | 4.15 |
| FID 105 | 1230 | 6.08 | 4.86 |
| FID 106 | 450 | 5.86 | 5.85 |
| Ref plot #1 | 1857 | 5.76 | 4.42 |
| Ref plot #2 | 672 | 6.72 | 6.18 |
| Ref plot #3 | 2457 | 5.78 | 3.83 |
| Ref plot #4 | 1418 | 7.84 | 6.02 |
| West Amendment Plot | 805 | 8.19 | 7.26 |

**TABLE 3-3
STSIU SOIL pCu VALUES**

**FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL**

| Location | Copper mg/kg | pH SU | pCu (calculated¹) |
|-----------------|-------------------------|------------------|---|
| ERA02 | 860 | 6.2 | 5.34 |
| ERA03 | 625 | 6.5 | 5.98 |
| ERA04 | 486 | 6.3 | 6.08 |
| ERA05 | 238 | 6.4 | 7.00 |
| ERA06 | 622 | 6.3 | 5.80 |
| ERA07 | 758 | 6.7 | 5.95 |
| ERA08 | 643 | 7 | 6.41 |
| ERA09 | 291 | 4.6 | 5.09 |
| ERA10 | 197 | 5.4 | 6.29 |
| ERA11 | 277 | 7 | 7.38 |
| ERA12 | 215 | 7.8 | 8.42 |
| ERA13 | 186 | 6.3 | 7.19 |
| ERA14 | 129 | 7.5 | 8.73 |
| ERA15 | 529 | 7.8 | 7.38 |
| STS-SS-2010-016 | 1120 | 4.9 | 3.82 |
| STS-SS-2010-017 | 2060 | 6 | 4.14 |
| STS-SS-2010-018 | 1100 | 6 | 4.87 |

Notes:

mg/kg = milligram per kilogram

SU = standard unit

¹ = pCu equation used from NewFields 2005

All samples taken from the 0-6" bgs interval

TABLE 4-1
SURFACE WATER HQs FOR DISSOLVED CADMIUM BASED ON AVAILABLE SITE DATA

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Stream Location | Year Sampled | Dissolved Cd (ug/L) | Final Hardness (mg/L) | Acute Criteria |
|-----------------------|--------------|---------------------|-----------------------|----------------|
| Martin Canyon | | | | |
| STS-CA-2010-008 | 2010 | 0.1 | 139 | 2.19 |
| STS-WS-2010-MC | 2010 | 0.1 | 141 | 2.21 |
| SW06A-2007 | 2007 | 0.1 | 25 | 0.51 |
| SW08-2007 | 2007 | 0.1 | 109 | 1.78 |
| SW07-2007 | 2007 | 0.1 | 97 | 1.61 |
| SW-06-2006 | 2006 | 0.3 | 41 | 0.77 |
| SW-07-2006 | 2006 | 0.2 | 90 | 1.51 |
| SW-08-2006 | 2006 | 0.2 | 152 | 2.36 |
| Rustler Canyon | | | | |
| STS-CA-2010-001 | 2010 | 0.1 | 73 | 1.26 |
| SW05-2007 | 2007 | 3.8 | 365 | 4.97 |
| SW09-2007 | 2007 | 0.1 | 119 | 1.92 |
| SW10-2007 | 2007 | 0.1 | 74 | 1.28 |
| SW-05-2006 | 2006 | 1.4 | 345 | 4.75 |
| SW-09-2006 | 2006 | 0.2 | 130 | 2.06 |
| SW-10-2006 | 2006 | 0.2 | 89 | 1.49 |
| SW-210-2006 | 2006 | 0.2 | 89 | 1.50 |
| SW-5-2004 | 2004 | 0.1 | 47 | 0.86 |
| Drainage A | | | | |
| STS-CA-2010-006 | 2010 | 0.1 | 37 | 0.71 |
| STS-WS-2010-A2 | 2010 | 0.2 | 32 | 0.62 |
| STS-WS-2010-A4 | 2010 | 0.1 | 30 | 0.59 |
| SW11-2007 | 2007 | 0.1 | 42 | 0.79 |
| SW12-2007 | 2007 | 0.1 | 54 | 0.98 |
| SW13-2007 | 2007 | 0.1 | 74 | 1.28 |
| SW14-2007 | 2007 | 0.1 | 26 | 0.52 |
| SW-11-2006 | 2006 | 0.2 | 41 | 0.78 |
| SW-12-2006 | 2006 | 0.2 | 37 | 0.71 |
| SW-13-2006 | 2006 | 0.2 | 48 | 0.89 |
| SW-14-2006 | 2006 | 0.39 | 27 | 0.54 |
| SW-214-2006 | 2006 | 0.3 | 27 | 0.54 |
| ERA45 | 2000 | 1.5 | 202 | 3.01 |
| ERA 25 | 2000 | 1.5 | 187 | 2.82 |
| SW-4-2004 | 2004 | 0.1 | 46 | 0.85 |
| Drainage B | | | | |
| STS-WS-2010-B-3 | 2010 | 0.1 | 111 | 1.81 |
| SW15-2007 | 2007 | 0.1 | 57 | 1.02 |
| SW-15-2006 | 2006 | 0.31 | 46 | 0.86 |

TABLE 4-1
SURFACE WATER HQs FOR DISSOLVED CADMIUM BASED ON AVAILABLE SITE DATA

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Stream Location | Year Sampled | Dissolved Cd (ug/L) | Final Hardness (mg/L) | Acute Criteria |
|----------------------|--------------|---------------------|-----------------------|----------------|
| Drainage C | | | | |
| STS-CA-2010-007 | 2010 | 0.1 | 400 | 5.38 |
| STS-WS-2010-005 | 2010 | 0.1 | 400 | 5.38 |
| STS-WS-2010-C-1 | 2010 | 0.2 | 62 | 1.10 |
| STS-WS-2010-C-2 | 2010 | 0.1 | 53 | 0.96 |
| STS-WS-2010-C-3 | 2010 | 0.1 | 57 | 1.02 |
| STS-WS-2010-C-4 | 2010 | 0.1 | 21 | 0.44 |
| BD4W-1-2007 | 2007 | 0.6 | 70 | 1.22 |
| CDW-1-2007 | 2007 | 1.3 | 35 | 0.67 |
| SW-16-2006 | 2006 | 0.3 | 400 | 5.38 |
| SW-216-2006 | 2006 | 0.3 | 400 | 5.38 |
| BD4W-1-2004 | 2004 | 1.2 | 68 | 1.19 |
| CDW-1-2004 | 2004 | 1.5 | 53 | 0.97 |
| Drainage D | | | | |
| STS-WS-2010-D1-1 | 2010 | 0.1 | 76 | 1.31 |
| STS-WS-2010-D1-2 | 2010 | 0.1 | 56 | 1.01 |
| STS-WS-2010-D2-1 | 2010 | 0.1 | 47 | 0.87 |
| Stock Tanks | | | | |
| STS-WS-2010-A1 | 2010 | 0.1 | 114 | 1.85 |
| STS-WS-2010-A3 | 2010 | 0.1 | 78 | 1.34 |
| STS-WS-2010-B-2 | 2010 | 0.1 | 145 | 2.27 |
| STS-WS-2010-D1-3 | 2010 | 0.1 | 61 | 1.08 |
| Stock Tank ERA39 | 2000 | 1.5 | 192 | 2.88 |
| Stock Tank ERA40 | 2000 | 1.5 | 45 | 0.83 |
| Stock Tank ERA41 | 2000 | 1.5 | 43 | 0.80 |
| Bayard Canyon | | | | |
| BC-01 | 2008 | 2 | 400 | 5.38 |
| Boltens Draw | | | | |
| ERA37 | 2000 | 1.5 | 103 | 1.69 |
| ERA38 | 2000 | 5.6 | 94 | 1.57 |
| West Drainage | | | | |
| SW04-2007 | 2007 | 0.1 | 83 | 1.41 |
| SW-6-2004 | 2004 | 0.1 | 96 | 1.59 |
| SW-04-2006 | 2006 | 0.3 | 54 | 0.98 |

Notes:

mg/L = milligram per liter

TABLE 4-2
SURFACE WATER HQs FOR DISSOLVED COPPER BASED ON AVAILABLE SITE DATA

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Stream Location | Year Sampled | Dissolved Cu (ug/L) | Final Hardness (mg/L) | Acute Criteria |
|-----------------------|--------------|---------------------|-----------------------|----------------|
| Martin Canyon | | | | |
| STS-CA-2010-000 | 2010 | 13.1 | 139 | 18.33 |
| STS-WS-2010-MC | 2010 | 11.1 | 141 | 18.58 |
| SW06A-2007 | 2007 | 30.1 | 25 | 3.64 |
| SW08-2007 | 2007 | 4.7 | 109 | 14.58 |
| SW07-2007 | 2007 | 8.1 | 97 | 13.06 |
| SW-06-2006 | 2006 | 19.7 | 41 | 5.76 |
| SW-07-2006 | 2006 | 15.1 | 90 | 12.20 |
| SW-08-2006 | 2006 | 5 | 152 | 19.95 |
| Rustler Canyon | | | | |
| STS-CA-2010-001 | 2010 | 2.7 | 73 | 9.99 |
| SW05-2007 | 2007 | 1220 | 365 | 45.52 |
| SW09-2007 | 2007 | 11 | 119 | 15.83 |
| SW10-2007 | 2007 | 2.6 | 74 | 10.12 |
| SW-05-2006 | 2006 | 55 | 130 | 17.16 |
| SW-09-2006 | 2006 | 9.1 | 89 | 12.00 |
| SW-10-2006 | 2006 | 4.1 | 89 | 12.09 |
| SW-210-2006 | 2006 | 2.5 | 47 | 6.54 |
| SW-5-2004 | 2004 | 60.6 | 47 | 6.54 |
| Drainage A | | | | |
| STS-CA-2010-006 | 2010 | 47 | 37 | 5.27 |
| STS-WS-2010-A2 | 2010 | 73.9 | 32 | 4.59 |
| STS-WS-2010-A4 | 2010 | 25 | 30 | 4.32 |
| SW11-2007 | 2007 | 39.7 | 42 | 5.93 |
| SW12-2007 | 2007 | 45.8 | 54 | 7.52 |
| SW13-2007 | 2007 | 45.6 | 74 | 10.12 |
| SW14-2007 | 2007 | 48.7 | 26 | 3.78 |
| SW-11-2006 | 2006 | 48.7 | 48 | 6.79 |
| SW-12-2006 | 2006 | 51.4 | 27 | 3.94 |
| SW-13-2006 | 2006 | 49.5 | 27 | 3.94 |
| SW-14-2006 | 2006 | 51.8 | 27 | 3.94 |
| SW-214-2006 | 2006 | 54.6 | 27 | 3.94 |
| ERA45 | 2000 | 10.8 | 202 | 26.07 |
| ERA 25 | 2000 | 15 | 187 | 24.24 |
| SW-4-2004 | 2004 | 37.1 | 46 | 6.48 |

**TABLE 4-2
SURFACE WATER HQs FOR DISSOLVED COPPER BASED ON AVAILABLE SITE DATA**

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Stream Location | Year Sampled | Dissolved Cu (ug/L) | Final Hardness (mg/L) | Acute Criteria |
|----------------------|--------------|---------------------|-----------------------|----------------|
| Drainage B | | | | |
| STS-WS-2010-B-3 | 2010 | 35.8 | 111 | 14.83 |
| SW15-2007 | 2007 | 52.2 | 57 | 7.91 |
| SW-15-2006 | 2006 | 72.1 | 46 | 6.52 |
| Drainage C | | | | |
| STS-CA-2010-007 | 2010 | 9.9 | 400 | 49.62 |
| STS-WS-2010-005 | 2010 | 10.3 | 400 | 49.62 |
| STS-WS-2010-C-1 | 2010 | 34.8 | 62 | 8.57 |
| STS-WS-2010-C-2 | 2010 | 36.6 | 53 | 7.39 |
| STS-WS-2010-C-3 | 2010 | 23.4 | 57 | 7.91 |
| STS-WS-2010-C-4 | 2010 | 53.1 | 21 | 3.09 |
| BD4W-1-2007 | 2007 | 80 | 70 | 9.60 |
| CDW-1-2007 | 2007 | 221 | 35 | 5.00 |
| SW-16-2006 | 2006 | 18.8 | 400 | 49.62 |
| SW-216-2006 | 2006 | 19.8 | 400 | 49.62 |
| SW-16-2006-AVG | 2006 | 19.3 | 400 | 49.62 |
| BD4W-1-2004 | 2004 | 207 | 68 | 9.37 |
| CDW-1-2004 | 2004 | 327 | 53 | 7.43 |
| Drainage D | | | | |
| STS-WS-2010-D1-1 | 2010 | 13 | 76 | 10.38 |
| STS-WS-2010-D1-2 | 2010 | 25 | 56 | 7.78 |
| STS-WS-2010-D2-1 | 2010 | 20 | 47 | 6.60 |
| Stock Tanks | | | | |
| STS-WS-2010-A1 | 2010 | 33.1 | 114 | 15.20 |
| STS-WS-2010-A3 | 2010 | 40.8 | 78 | 10.63 |
| STS-WS-2010-B-2 | 2010 | 73.9 | 145 | 19.07 |
| STS-WS-2010-D1-3 | 2010 | 33.6 | 61 | 8.40 |
| Stock Tank ERA39 | 2000 | 28 | 192 | 24.85 |
| Stock Tank ERA40 | 2000 | 25.6 | 45 | 6.27 |
| Stock Tank ERA41 | 2000 | 28.6 | 43 | 6.07 |
| Bayard Canyon | | | | |
| BC-01 | 2008 | 35.4 | 400 | 49.62 |
| Boltens Draw | | | | |
| ERA37 | 2000 | 64.8 | 103 | 13.82 |
| ERA38 | 2000 | 150 | 94 | 12.68 |
| West Drainage | | | | |
| SW04-2007 | 2007 | 129 | 83 | 11.28 |
| SW-6-2004 | 2004 | 95.4 | 96 | 12.89 |
| SW-04-2006 | 2006 | 220 | 54 | 7.51 |

Notes:

mg/L = milligram per liter

TABLE 4-3
SURFACE WATER HQs FOR DISSOLVED LEAD BASED ON AVAILABLE SITE DATA

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Stream Location | Year Sampled | Dissolved Pb (ug/L) | Final Hardness (mg/L) | Acute Criteria |
|-----------------------|--------------|------------------------|--------------------------|----------------|
| Martin Canyon | | | | |
| STS-CA-2010-008 | 2010 | 0.6 | 139 | 92.25 |
| STS-WS-2010-MC | 2010 | 0.5 | 141 | 93.68 |
| SW06A-2007 | 2007 | 0.1 | 25 | 13.88 |
| SW08-2007 | 2007 | 0.1 | 109 | 70.93 |
| SW07-2007 | 2007 | 0.1 | 97 | 62.47 |
| SW-06-2006 | 2006 | 1.7 | 41 | 23.95 |
| SW-07-2006 | 2006 | 2.4 | 90 | 57.72 |
| SW-08-2006 | 2006 | 2.4 | 152 | 101.61 |
| Rustler Canyon | | | | |
| STS-CA-2010-001 | 2010 | 0.2 | 73 | 45.77 |
| SW05-2007 | 2007 | 0.3 | 365 | 255.61 |
| SW09-2007 | 2007 | 0.1 | 119 | 78.01 |
| SW10-2007 | 2007 | 0.1 | 74 | 46.46 |
| SW-5-2004 | 2004 | 1.8 | 47 | 27.85 |
| SW-05-2006 | 2006 | 3 | 345 | 241.47 |
| SW-09-2006 | 2006 | 2.4 | 130 | 85.57 |
| SW-10-2006 | 2006 | 2.4 | 89 | 56.64 |
| SW-210-2006 | 2006 | 2.4 | 89 | 57.13 |
| Drainage A | | | | |
| ERA45 | 2000 | 20 | 202 | 137.59 |
| ERA 25 | 2000 | 20 | 187 | 126.75 |
| STS-CA-2010-006 | 2010 | 0.3 | 37 | 21.55 |
| STS-WS-2010-A1 | 2010 | 0.2 | 114 | 74.46 |
| STS-WS-2010-A2 | 2010 | 1.2 | 32 | 18.32 |
| STS-WS-2010-A3 | 2010 | 0.1 | 78 | 49.22 |
| STS-WS-2010-A4 | 2010 | 0.3 | 30 | 17.04 |
| SW11-2007 | 2007 | 0.1 | 42 | 24.82 |
| SW12-2007 | 2007 | 0.3 | 54 | 32.82 |
| SW13-2007 | 2007 | 0.1 | 74 | 46.46 |
| SW14-2007 | 2007 | 0.3 | 26 | 14.51 |
| SW-11-2006 | 2006 | 2.4 | 41 | 24.45 |
| SW-12-2006 | 2006 | 2.4 | 37 | 21.59 |
| SW-13-2006 | 2006 | 2.4 | 48 | 29.09 |
| SW-14-2006 | 2006 | 3.7 | 27 | 15.25 |
| SW-214-2006 | 2006 | 1.9 | 27 | 15.25 |
| SW-4-2004 | 2004 | 1.8 | 46 | 27.55 |

TABLE 4-3
SURFACE WATER HQs FOR DISSOLVED LEAD BASED ON AVAILABLE SITE DATA

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Stream Location | Year Sampled | Dissolved Pb (ug/L) | Final Hardness (mg/L) | Acute Criteria |
|----------------------|--------------|------------------------|--------------------------|----------------|
| Drainage B | | | | |
| STS-WS-2010-B-2 | 2010 | 0.5 | 145 | 96.55 |
| STS-WS-2010-B-3 | 2010 | 0.1 | 111 | 72.34 |
| SW15-2007 | 2007 | 0.2 | 57 | 34.84 |
| SW-15-2006 | 2006 | 2 | 46 | 27.75 |
| Drainage C | | | | |
| STS-CA-2010-007 | 2010 | 0.1 | 400 | 280.85 |
| STS-WS-2010-005 | 2010 | 0.1 | 400 | 280.85 |
| STS-WS-2010-C-1 | 2010 | 0.1 | 62 | 38.24 |
| STS-WS-2010-C-2 | 2010 | 0.1 | 53 | 32.15 |
| STS-WS-2010-C-3 | 2010 | 0.2 | 57 | 34.84 |
| STS-WS-2010-C-4 | 2010 | 0.2 | 21 | 11.40 |
| BD4W-1-2007 | 2007 | 0.5 | 70 | 43.71 |
| CDW-1-2007 | 2007 | 0.2 | 35 | 20.25 |
| BD4W-1-2004 | 2004 | 1.8 | 68 | 42.47 |
| CDW-1-2004 | 2004 | 1.8 | 53 | 32.34 |
| SW-16-2006 | 2006 | 3.5 | 400 | 280.85 |
| SW-216-2006 | 2006 | 2.6 | 400 | 280.85 |
| Drainage D | | | | |
| STS-WS-2010-D1-1 | 2010 | 0.3 | 76 | 47.84 |
| STS-WS-2010-D1-2 | 2010 | 0.1 | 56 | 34.17 |
| STS-WS-2010-D1-3 | 2010 | 0.4 | 61 | 37.56 |
| STS-WS-2010-D2-1 | 2010 | 0.2 | 47 | 28.13 |
| Stock Tanks | | | | |
| Stock Tank ERA39 | 2000 | 20 | 192 | 130.36 |
| Stock Tank ERA40 | 2000 | 20 | 45 | 26.48 |
| Stock Tank ERA41 | 2000 | 20 | 43 | 25.48 |
| Bayard Canyon | | | | |
| BC-01 | 2008 | 0.3 | 400 | 280.85 |
| Boltons Draw | | | | |
| ERA37 | 2000 | 20 | 103 | 66.69 |
| ERA38 | 2000 | 20 | 94 | 60.37 |
| West Drainage | | | | |
| SW04-2007 | 2007 | 0.2 | 83 | 52.69 |
| SW-6-2004 | 2004 | 1.8 | 96 | 61.54 |
| SW-04-2006 | 2006 | 2 | 54 | 32.76 |

Notes:

mg/L = milligram per liter

**TABLE 5-1
SOIL REMEDIAL TECHNOLOGIES**

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| NO. | REMEDIAL TECHNOLOGY | DESCRIPTION | PRELIMINARY SCREENING | | | CONCLUSION |
|-----|--|---|---|---|--|--|
| | | | EFFECTIVENESS | IMPLEMENTABILITY | COST | |
| 1 | No Action | No further active response actions. | Contaminants will naturally attenuate over time. Does not provide additional mechanisms to prevent contaminant exposure to site receptors. | Is considered implementable. | There are no cost associated with no action. | Being retained for baseline comparison of remedial technologies. |
| 2 | Monitoring | No further active response actions. Monitoring will be conducted to prove the occurrence of natural remediation. | Contaminants will naturally attenuate over time. Does not provide additional mechanisms to prevent contaminant exposure to site receptors. | Is considered implementable. | Costs are associated with types of monitoring (quantitative and/or qualitative) and monitoring duration selected. | Being retained for evaluation as a part of a remedial alternative. |
| 3 | Excavation and Reuse | Excavation and onsite management includes removal of contaminated soils with heavy construction equipment and hand removal techniques. Excavated soils will be managed onsite at the waste rock stockpiles or reused in the adjacent operational areas as cover for the tailings ponds. | Is considered highly effective at reducing the presence of site contaminants. | Is considered to be generally technically implementable with the exception of certain areas of the site that are more difficult to access with equipment and personnel due to terrain conditions. | Costs include equipment use and maintenance, material handling and transport, and backfill materials and activities. Costs are considered less than Excavation and Disposal option because offsite transportation and disposal is not needed. Long term O&M costs are considered to be low. | Being retained for evaluation as a part of a remedial alternative. |
| 3a | Excavation and Disposal | Excavation and disposal includes removal of contaminated soils with heavy construction equipment and hand removal techniques. Excavated soils will be characterized to determine final offsite disposition. | Is considered highly effective at reducing the presence of site contaminants. | Excavation is considered to be generally technically implementable with the exception of certain areas of the site that are more difficult to access with equipment and personnel due to terrain conditions. Offsite transportation is not considered to be economical to a permitted facility that could accept the soils. Therefore the offsite transportation and disposal is considered to have low implementability. | Costs include equipment use and maintenance, material handling and transport, backfill materials and activities, characterization, and offsite transportation and disposal. Long term O&M costs are considered to be low. | Being retained for further evaluation. |
| 4 | Soil Amendments | | | | | |
| 4a | Limestone and Organic Matter | Ongoing study testing combinations of lime slurry and organic matter, and tilling applications. Plant coverage, pH, and soil chemistry being monitored. Currently starting year three of the five year study. | The overall effectiveness will be determined upon completion of the ongoing amendment study. | This technology has been demonstrated to be implementable via the ongoing amendment study. This technology may be less implementable at certain areas of the site that are not readily accessible by equipment. | Costs will depend on the results of the ongoing amendment study. However, minimal soil handling is required as soils generally remain in place, minimizing transportation and disposal costs. Long term O&M costs are considered low to moderate. | Being retained for evaluation as a part of a remedial alternative. |
| 4b | Tilling | Tilling provides additional dilution of metals and has potential to raise alkaline pH conditions to more neutral pH conditions pending existing pH levels within the soil treatment area being tilled. Plant coverage, pH, and soil chemistry would be monitored post-tilling operations. | Is potentially effective at raising alkaline pH conditions and making contaminants less bioavailable to site receptors without the introduction of lime and/or organic matter. | This technology has been demonstrated to be implementable via the ongoing amendment study. This technology may be less implementable at certain areas of the site that are not readily accessible by equipment for tilling (i.e., areas with too steep of a slope) | Tilling includes increased efforts and costs as compared to adding lime and organic matter without tilling. However, minimal soil handling is required as soils generally remain in place, minimizing transportation and disposal costs compared to excavation and soil cover. Long term O&M costs are considered low to moderate. | Being retained for evaluation as a part of a remedial alternative. |
| 4c | Ferrihydrite | Ferrihydrite is mixed into the impacted soils to reduce the copper bioavailability to site receptors. | Effectiveness would be determined via conducting a pilot treatability study and potentially bench scale treatability study to determine the loading rate of ferrihydrite or if other amendments such as lime or magnesium oxide (MgO) would be beneficial in buffering the pH. Because iron is being introduced to the soils, evaluations would be conducted to verify that the iron levels are acceptable from a human | This technology is considered to be implementable, based on the ongoing soil amendment study which has demonstrated that soil mixing is feasible. A pilot treatability study would be required to determine the most effective soil mixing technique. | Cost will depend on soil mixing technique determined and market value of the amendment materials. The overall technology is considered to have moderate costs and is comparable to the costs of the lime and OM amendments being tested as part of the Amendment Study. Long term O&M are considered low to moderate. | Being retained for evaluation as a part of a remedial alternative. Pilot and/or bench treatability studies will not be conducted at this time. |
| 4d1 | Use of Chelating Agent: Soil Washing (Ex-Situ) | Ex-situ soil washing includes removal of contaminants from soil using separation methodologies, including "washing" the soils with a detergent and/or chelating agent solution. The resulting clean portions of soil can be returned to the site for reuse and the resulting wash mixture and contaminated soil fines would be characterized for final disposition. | Is potentially effective at removing copper from soil. However, level of effectiveness would have to be verified via a pilot treatability study. | A pilot treatability study would be required to determine implementability. Factors to consider to evaluate implementability include, but are not limited to, accessibility of soil washing materials (e.g., water source) and equipment to areas of remediation. | Ex-Situ soil washing is labor intensive and requires a high level of soil handling (excavation, washing, soil replacement). Requires disposal of used wash solution and potentially portions of soil. Cost savings include utilizing remediated soil for onsite reuse, reducing imported backfill required. | Not being retained for further evaluation. |
| 4d2 | Use of Chelating Agent: Soil Washing (In-Situ) | In-situ soil washing includes introducing a chelating agent into the soil. The objective of the chelating agent is to mobilize the copper within the soil column. The copper becomes soluble within the groundwater and the groundwater is subsequently extracted for treatment and/or disposal with a groundwater extraction system. | Is potentially effective at removing copper from soil. However, level of effectiveness would have to be verified via a pilot treatability study. | Due to the large areas needing remediation and lack of current infrastructure to support a groundwater extraction system, this is considered to have low implementability. However, a pilot treatability study would be required to determine implementability. | In-Situ soil washing is labor intensive and requires the introduction of the chelating agent into the soils, installation of groundwater extraction system, and extracted groundwater treatment and/or disposal. Costs for construction and future O&M activities are considered very high. | Not being retained for further evaluation. |

**TABLE 5-1
SOIL REMEDIAL TECHNOLOGIES**

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| NO. | REMEDIAL TECHNOLOGY | DESCRIPTION | PRELIMINARY SCREENING | | | CONCLUSION |
|-----|---|---|--|--|---|--|
| | | | EFFECTIVENESS | IMPLEMENTABILITY | COST | |
| 4d3 | Use of Chelating Agent: Phytoextraction | Phytoextraction includes the planting of specified seeds and plants to uptake the contaminants through the root system into the plant tissue. The plants are then harvested on a regular basis to remove the contaminants from the site. A chelating agent can be applied to the soil to increase the rate of contaminant uptake into the plants. | Is potentially effective at removing copper from soil. Phytoaccumulation of contaminants in seeds and vegetation has potential to directly expose site receptors to contaminants. The effectiveness of contaminant removal is directly dependent on the success of the plants and the rate of contaminant uptake. | A pilot treatability study would be required to determine implementability. Factors to evaluate implementability include, but are not limited to, types of seeds and vegetation, harvesting and replanting schedule, chelating agent, and rate of contaminant uptake. | Initial costs are considered low to moderate and include costs of seeds/plants, chelating agent, and planting. O&M is considered high due to the long term harvesting and replanting schedule, maintenance of the plants, and disposal of the plant waste. Costs are considered moderate to high as compared to other technologies. | Not being retained for further evaluation. |
| 5a | Soil Cover | A soil cover involves isolating impacted soils from potential site receptors. The soil cover would consist of clean soil and would be constructed over soils with copper levels above the site RAC to serve as a physical barrier between contaminated soils and site receptors. In addition, the cover could be constructed in areas of exposed bedrock to create pre-existing habitat for site receptors. | Is effective at protecting site receptors from underlying contaminants. Contaminants will remain onsite requiring ICs to restrict future intrusive activity practices. Maintenance of BMPs is considered critical to maintain the integrity and effectiveness of the soil cover. | Is considered to be generally technically implementable with the exception of certain areas of the site that are more difficult to access with equipment and personnel due to terrain conditions. | Costs are considered moderate as compared to soil excavation and the soil amendment technologies. There are higher initial costs associated with soil handling and placement of the cover. However, there are no costs associated with excavation or soil amending. O&M costs related to maintaining the cover are considered moderate. | Being retained for evaluation as a part of a remedial alternative. |
| 5b | Impermeable Cover | An impermeable cover, such as asphalt or concrete, placed over targeted impacted soils would greatly minimize or eliminate the potential for direct contact of site receptors with impacted site soils. | An impermeable cover would be effective at reducing exposure of site receptors to impacted soils. However, an impermeable cover would eliminate the vegetative landscape, potential for future grazing, and would impact surface water infiltration and stormwater runoff patterns. | Installation of an impermeable cover is generally considered implementable with exception of areas that are too steep and/or areas with varying topography that can not be graded to conditions that could accommodate the cover. | Costs include surface preparation and grading, and installation of the impermeable cover, including base materials. Costs are considered to be moderate as compared to other soil remedial technologies. Long term O&M costs are considered low. | Not being retained for further evaluation. |
| 6 | Surface Soil Controls: Phytostabilization | Surface soil controls includes stabilizing surface soils to prevent or lower airborne dispersion of impacted soils and provide erosion control. Phytostabilization is considered a method to stabilize the surface soils through revegetation. Phytostabilization consists of revegetating the impacted areas with plant species targeted at increasing long term stabilization as compared to existing vegetative conditions. | Phytostabilization has the potential to be effective at stabilizing the soils and reducing transport of impacted soils. However, this technology used alone would not be effective at reducing site contaminant levels and/or exposure to site receptors. This could be effectively be used in conjunction with other remedial technologies. | Revegetating soils with species that are targeted at soil stabilization is generally considered implementable at the Site. There may be certain areas of the site that may not support the phytostabilization species (due to slopes, percent soil coverage, and soil conditions). Plant species and potential locations would be determined during the remedial design process. | Costs include the costs of the individual plants, planting, and limited O&M. O&M is considered moderate the first 3 to 5 years, or until the vegetation is considered to be established. O&M is considered to be low once the vegetation has been established. Costs are considered moderate compared to other technologies. | Being retained for evaluation as part of a remedial alternative. |
| 7 | Phytoremediation | Phytoremediation consists of planting vegetation that can uptake the contaminants located in the soil and subsequently remediate the soils. Plants and/or trees would be selected that are able to bioaccumulate and/or degrade the site contaminants. | Phytoremediation is potentially effective at remediating site contaminants. Contaminant reduction would take several years to achieve and would not immediately reduce potential exposure to site receptors. A preliminary remedial design evaluation would be required to determine if the naturally existing conditions at the site (e.g., humidity, access to groundwater, soil conditions) could support phytoremediation plant species. | Assuming that the naturally occurring site conditions can support phytoremediation plant species, phytoremediation is generally considered implementable at the Site. There may be certain areas of the site that may not support the phytoremediation species (due to slopes, percent soil coverage, access to groundwater, and soil conditions). | Costs include the cost of the individual plants/trees, planting, and O&M. O&M is considered moderate to high, as remediation of the site contaminants is directly dependent on the success of the plants/trees to thrive over an extended period of time. Costs are considered moderate to high as compared to other technologies. | Not being retained for further evaluation |
| 8 | Electrokinetic Remediation | Electrokinetics is based on the principle that when direct current (DC) is passed through contaminated soil, certain (negatively charged) types of contaminants will migrate through the soil pore water to a place where they can be removed. This alternative uses electrode assemblies that are installed in the ground in a square array and connected to a DC voltage power supply. Each electrode assembly contains water, a pump, an electrode, and various controllers and sensors. The outer casing of the electrodes is made of porous ceramic through which the electrical current and contaminants pass. A vacuum is applied to the casings which keeps the water inside the assembly from flowing out and saturating adjacent soils. | Overall effectiveness of using electrokinetic remediation would need to be determined by conducting a pilot and potentially a bench scale treatability study. Factors that would be evaluated during the treatability studies would include, but would not be limited to, voltage rates, effectiveness in soils with low moisture content, and the increased acidity to the treated soil. | Electrokinetic remediation has not been tested at the site, so currently is considered low for implementability. A pilot treatability study would need to be conducted to determine if the low soil moisture content in the soil would support the removal of copper and if the increased soil acidity would impact vegetative species. | The cost associated with electrokinetic remediation is assumed to be moderate to high. Factors such as the spacing and number of electrodes would be determined during a pilot treatability study, could greatly impact the costs for this technology. Therefore, without the results of a pilot study the overall cost of implementation cannot be determined. | Not being retained for further evaluation |

**TABLE 6-1
SURFACE WATER REMEDIAL TECHNOLOGIES**

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| NO. | REMEDIAL TECHNOLOGY | DESCRIPTION | PRELIMINARY SCREENING | | | CONCLUSION |
|-----|--|---|---|--|---|--|
| | | | EFFECTIVENESS | IMPLEMENTABILITY | COST | |
| 1 | No Action | No further active response actions for surface water. | Contaminants will naturally attenuate over time. Does not provide additional mechanisms to prevent contaminant exposure to site receptors. | Is considered implementable. | There are no costs associated with no action. | Being retained for baseline comparison of remedial technologies. |
| 2 | Monitoring | No further active response actions for surface water. Monitoring to be conducted to prove the occurrence of natural remediation. | Contaminants will naturally attenuate over time. Does not provide additional mechanisms to prevent contaminant exposure to site receptors. | Is considered implementable. | Costs are associated with types of monitoring (quantitative and/or qualitative) and monitoring durations selected. | Being retained for evaluation as a part of a remedial alternative. |
| 3 | Excavation (In-Drainage, Upland, or Stock Ponds) | Excavation includes removing impacted in-drainage sediments and/or upland soils determined to be contributing to surface water impacts. | Is considered highly effective at reducing the presence of site contaminants. | Is considered to be generally technically implementable with the exception of certain areas of the site that are more difficult to access with equipment and personnel due to terrain conditions and presence of mature trees. | Costs include equipment use and maintenance, material handling and transport, and characterization and final disposition. Long term O&M costs related to BMPs are considered to be low to moderate. | Being retained for evaluation as a part of a remedial alternative. |
| 4 | In-Stream Removal of Suspended Sediments | Consists of construction of settling basins within the stream drainage areas to allow for sediments to descend to bottom of the pool and accumulate. Accumulated impacted sediments would be removed by mechanical methods. | Is considered to be effective at capturing contaminated sediments. Settling pools currently exist on site and have demonstrated effectiveness in capturing contaminated sediments | Is considered to be technically implementable. Some portions of drainage areas may be restricted from construction of pools due to equipment accessibility restrictions. | Costs are considered to be moderate during construction of the settling pools. Long term O&M costs are considered to be moderate to high as compared to excavation and surface water treatment. | Being retained for evaluation as a part of a remedial alternative. |
| 5 | Limestone Treatment | Consists of installation of features, such as limestone, within the surface water drainage pathway. As the surface water passes over the feature (e.g., limestone) the pH is elevated, subsequently making the contaminants (copper) less bioavailable to site receptors. | Is considered effective at raising surface water pH as long as surface water makes contact with the limestone features. | Is considered to be technically implementable. Some portions of drainage areas may be restricted from installation of limestone features due to equipment accessibility restrictions. | Costs are considered to be high during construction of the limestone features. Long term O&M costs are considered to be low compared to excavation and in-stream removal of suspended sediments. | Being retained for evaluation as a part of a remedial alternative. |
| 6 | Alkaline Washing | Consists of insertion of alkaline fluid into the sediments and banks of the drainage. The alkaline wash will raise pH and sequester metals in the sediments, subsequently reducing mobilization of the contaminants (copper) to surface water. | Is considered effective at raising pH and lowering metals concentrations in surface water as long as the majority of metals loading is coming from sediments. | Is considered to have low implementability. There are large infrastructure requirements and some portions of the drainage area may be restricted due to equipment accessibility restrictions. | Costs are considered to be high both during the construction and O&M phases when compared to other remedial options. | Not being retained for evaluation as a part of a remedial alternative. |
| 7 | Sediment and Erosion Control | Consists of construction of ditches, berms, and other controls (e.g., sedimentation controls) to prevent surface water run-on to the impacted areas and run-off from the impacted areas. | Is considered effective at minimizing the transport of contaminants to and from the drainage areas and surface water. | Is considered to be technically implementable in the drainage area and upland portions of the Site with exception to areas that may be inaccessible to equipment and personnel. | Construction costs are considered to be low to moderate. Long term O&M costs associated with maintenance, repair, and replacement of controls are considered to be low to moderate compared to other surface water remedial technologies. | Being retained as a component of remedial alternatives. |

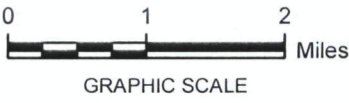
FIGURES





LEGEND

- Smelter Tailing boundary
- Stockpiles
- City Areas
- Major Roads
- Railroad
- Town Roads



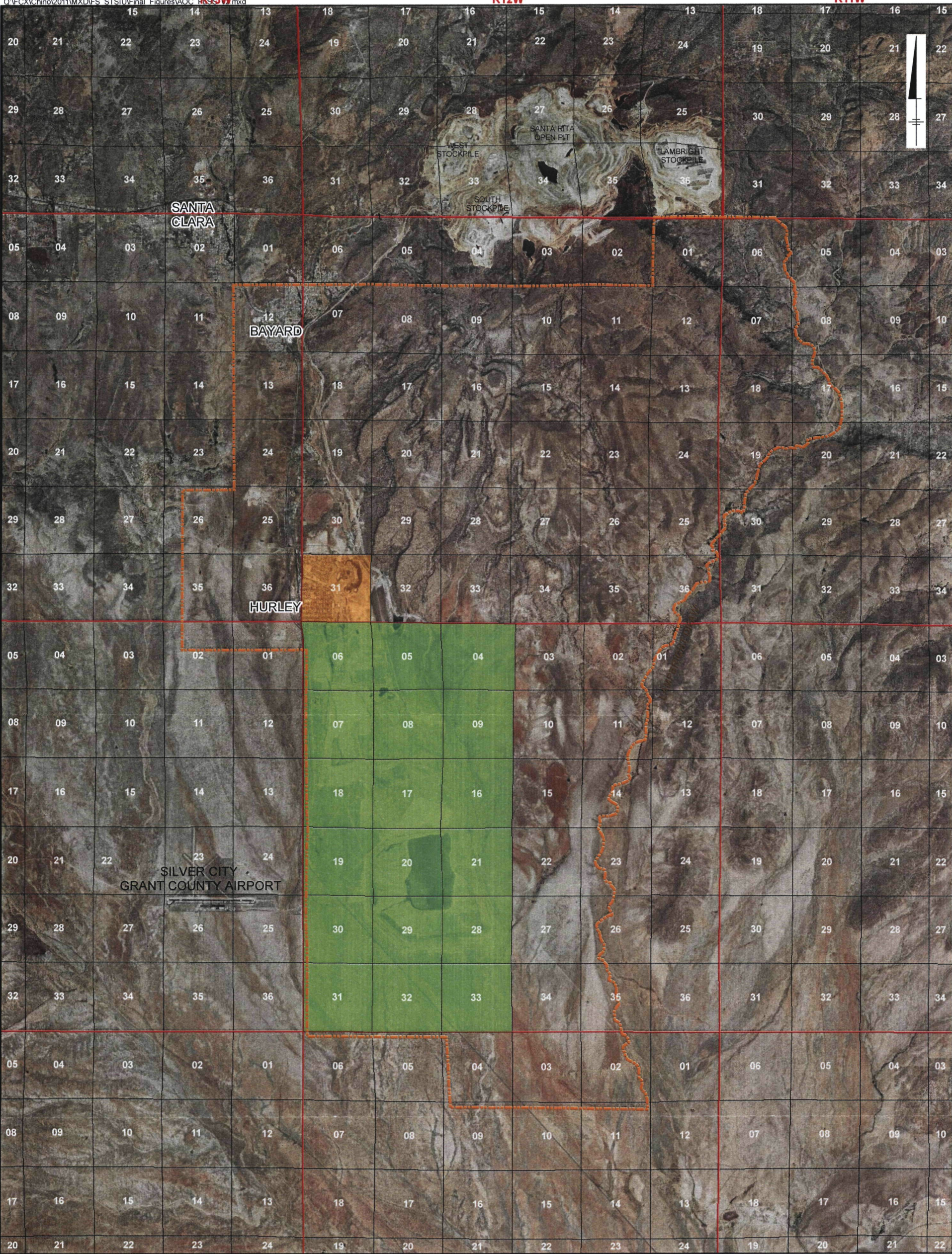
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VANADIUM, NEW MEXICO

SMELTER/TAILINGS SOILS IUF S PROPOSAL

SITE OVERVIEW

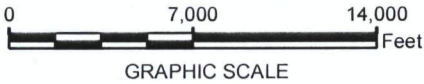


FIGURE
1-1



LEGEND:

- Township-Range Boundaries
- Section Boundaries
- Smelter Investigation Unit Section
- Tailing Impacted Soils Investigation Unit Sections
- STSIU Study Boundary



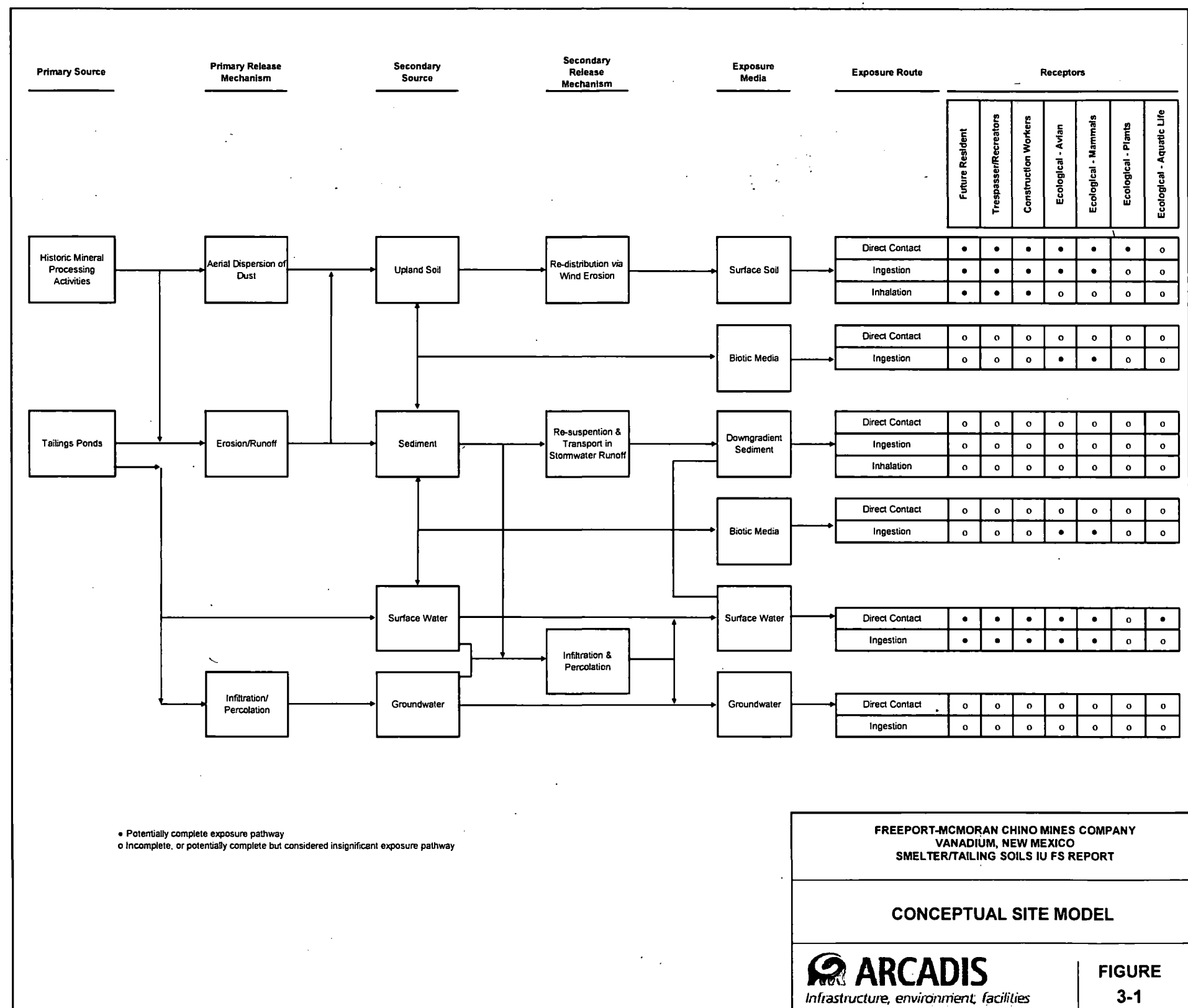
FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

SMELTER/TAILINGS SOILS IU FS PROPOSAL

STSIU STUDY BOUNDARY
AND INVESTIGATION AREA



FIGURE
2-1





LEGEND:

| Copper Concentration (mg/kg) | |
|------------------------------|-----------------------------|
| ● <327 | ● 1,600 - 2,700 |
| ● 327 - 800 | ● 2,700 - 5,000 |
| ● 800 - 1,100 | ● >5,000 |
| ● 1,100 - 1,600 | ■ Smelter Tailings Boundary |
| | — Major Roads |
| | — Railroad |



FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

SMELTER/TAILINGS SOILS IUFSS PROPOSAL

**STSIU SAMPLE LOCATIONS AND COPPER
CONCENTRATIONS IN SOILS (0-6 INCHES)**



**FIGURE
3-2**



LEGEND

- Iron Concentration (mg/kg)
- <40,000
 - 40,000 - 70,000
 - 70,000 - 100,000
 - >100,000
- Smelter Tailing boundary
- Major Roads
- Railroad



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SMELTER/TAILINGS SOILS IU FS PROPOSAL

**STSIU SAMPLE LOCATIONS AND IRON
CONCENTRATIONS IN SOILS (0-6 INCHES)**

ARCADIS

FIGURE
3-3



LEGEND:

| | | | |
|------------|-----------|--|---------------------------|
| pCu | | | |
| 3.0 - 4.0 | 4.6 - 4.8 | | Smelter Tailings Boundary |
| 4.0 - 4.2 | 4.8 - 5.0 | | Railroad |
| 4.2 - 4.4 | >5.0 | | Major Roads |
| 4.4 - 4.6 | | | |

0 1 2 Miles
GRAPHIC SCALE

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SMELTER/TAILINGS SOILS IU FS PROPOSAL

**STSIU SAMPLE LOCATIONS AND
pCu IN SOILS (0-6 INCHES)**

ARCADIS

FIGURE
3-4

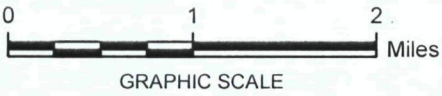


LEGEND

Stock Tank Type

- Large Dirt Embankment Tank
- Medium Dirt Embankment Tank
- Small Dirt Embankment Tank

- Spring Seep
- Tank Trough
- Undefined Stock Tank
- Windmill



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SMELTER/TAILINGS SOILS IU FS PROPOSAL

STSIU SURFACE WATER



FIGURE
4-1



LEGEND

- Sample Location
- Smelter Tailings Boundary
- Drainages
- City Areas
- Major Roads
- Town Roads
- Railroad



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SMELTER/TAILINGS SOILS IU FS PROPOSAL
**SURFACE WATER SAMPLE
LOCATIONS WITH CADMIUM
HQ VALUES >1**



FIGURE
4-2



LEGEND

- Sample Location
- Smelter Tailings Boundary
- Drainages
- Major Roads
- Town Roads
- Railroad
- City Areas

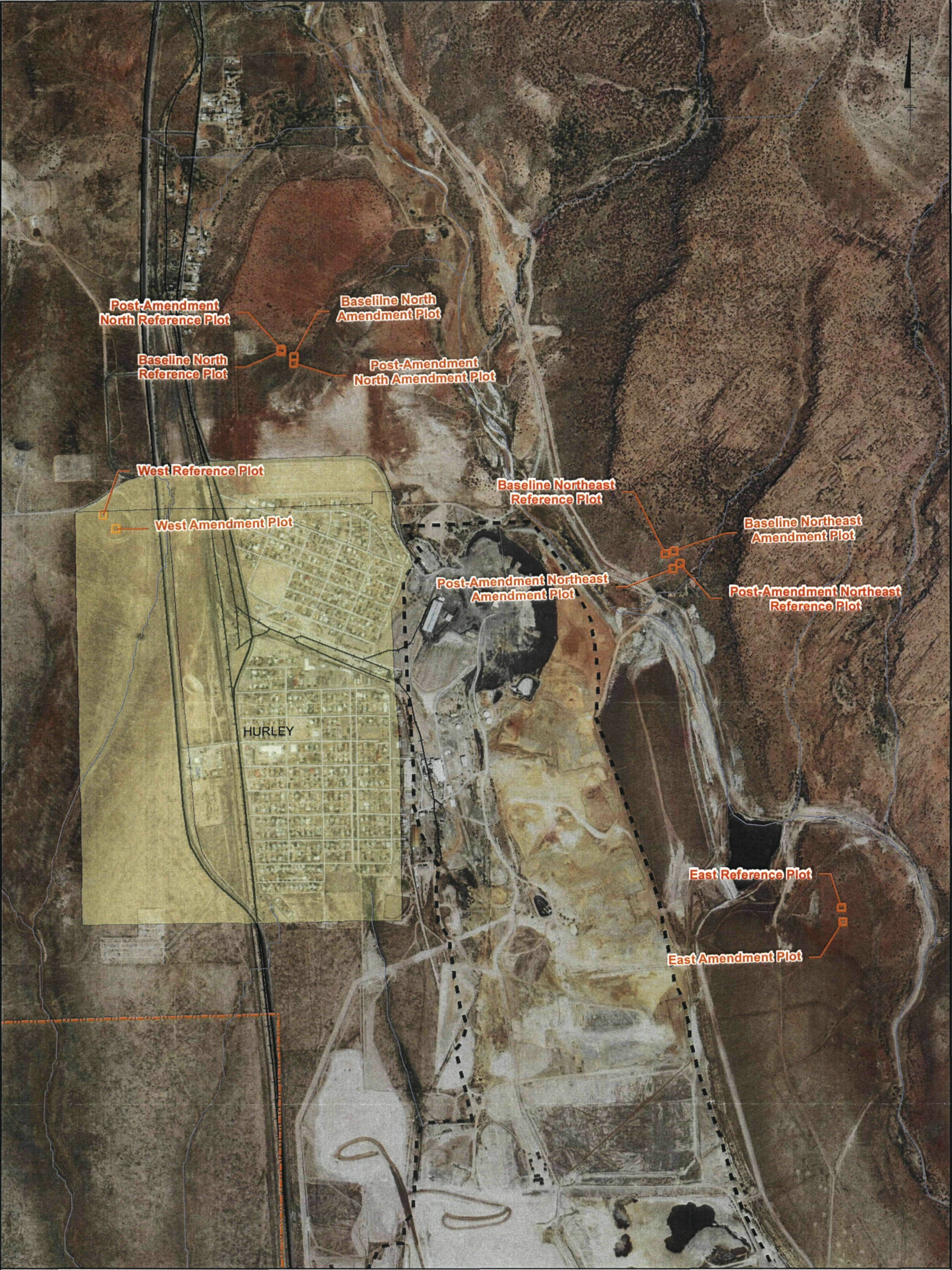
0 1.25 2.5 Miles

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SMELTER/TAILINGS SOILS IU FS PROPOSAL
**SURFACE WATER SAMPLE
LOCATIONS WITH COPPER
HQ VALUES >1**

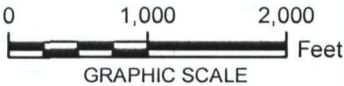


FIGURE
4-3



LEGEND:

- | | |
|---|--|
|  Amendment Areas |  STSIU Boundary |
|  City Areas |  Major Roads |
|  Smelter Tailings Boundary |  Town Roads |
|  Stockpiles |  Railroad |
| |  Drainages |



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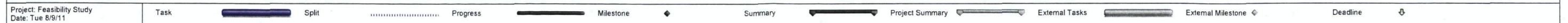
SMELTER/TAILINGS SOILS IU FS PROPOSAL

AMENDMENT STUDY
PLOT LOCATIONS



FIGURE
5-1

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APPENDIX A



APPENDIX A – FIELD SAMPLING PLAN: UPLAND SOIL

| | | |
|------------|---|-----------|
| A.1 | Introduction | 3 |
| A.2 | Site Background | 3 |
| A.3 | Sampling Objectives | 5 |
| A.4 | Data Quality Objectives: Soil Sampling | 5 |
| A4.1 | Problem Statement and Decision Criteria Identification | 6 |
| A4.2 | Decision Inputs | 9 |
| A4.3 | Boundary, Decision Rule, and Limits on Decision Errors..... | 11 |
| A4.4 | Optimal Design for Obtaining Data..... | 13 |
| | Plant RAC Sampling..... | 13 |
| | pCu Sampling Design..... | 13 |
| | Vegetation Sampling Design | 14 |
| | Small Ground Feeding Bird RAC Sampling | 16 |
| | Upland Copper Sampling Design | 16 |
| | Human Health RAC Sampling | 18 |
| A.5 | Sample Designation | 18 |
| A.6 | Sample Equipment and Procedures..... | 18 |
| A6.1 | General SOPs..... | 18 |
| A6.2 | Soil SOPs..... | 19 |
| A6.3 | Survey of Sample Locations..... | 20 |
| A6.4 | Vegetation SOPs..... | 20 |
| A.7 | Sample Handling and Analysis..... | 20 |
| A.8 | Processing of Results | 21 |
| A8.1 | Spatial Interpolation of pCu..... | 21 |
| A8.2 | Spatial Interpolation to Define 95 UCL Copper in Exposure Units | 22 |
| A8.3 | Evaluation of Remote Sensing for Rangeland and Wildlife Habitat Quality in areas with low pCu | 22 |
| A.9 | References..... | 24 |

Tables

| | |
|----------|--|
| Table 1. | Criteria used to define Observed Apparent Trend (OAT) score |
| Table 2 | OAT scores, percent foliar cover, and acreage for each rangeland polygon with potential pCu < 5 |
| Table 3 | Copper Results Comparison of 0-1 to 0-6 inch Soils Samples |
| Table 4 | Acreages of vegetation polygons with samples that have Cu > 1600 mg/kg |
| Table 5 | Statistics calculated on pCu and Copper samples within area of uncertainty to estimate sample size (N) |
| Table 6 | Coordinates of proposed samples (to be provided at finalization of sample plan). |

Figures

| | |
|----------|---|
| Figure 1 | Approximate distribution of pCu concentrations based upon existing data and rangeland polygons used as exposure units. |
| Figure 2 | Approximate distribution of Copper concentrations based upon existing data and vegetation polygons used as exposure units |
| Figure 3 | Rangeland condition based on OAT score, and location of ERA sample within pCu <5 contour and proposed vegetation samples for calibrating and testing remote sensing maps of rangeland/wildlife habitat quality. |
| Figure 4 | Regression Model for Copper 0-1 inch verses 0-6 inch Samples |
| Figure 5 | Vegetation map showing proposed sample locations for delineating ephemeral drainage exposure units for Copper. |
| Figure 6 | Area of uncertainty and proposed sample locations for pCu |
| Figure 7 | Area of uncertainty and proposed sample locations for Copper |
| Figure 8 | Distribution of percent slope categories |
| Figure 9 | Decision tree for interpolation method used to estimate 95 UCL in exposure units |

A.1 Introduction

The purpose of this Field Sampling Plan (FSP) is to document the tasks and methodology by which sampling activities will be conducted to fulfill the upland data needs identified in the Smelter/Tailing Soils Unit (STSIU) Feasibility Study (FS) Proposal. This FSP is designed to generate data necessary to evaluate the area affected by Pre-FS remedial action criteria (RAC) issued by New Mexico Environment Department (NMED) on March 3, 2011. This FSP describes the objectives of the proposed investigation, and defines the sampling, analysis, and data gathering methods to be used in the field investigation. The FSP also references the policy, functional activities and quality assurance/quality control (QA/QC) protocols to be used in the investigation, which are specifically stated in the RI Quality Assurance Plan (QAP) (Chino, 1997a).

The QAP defines how site-wide QA/QC activities will be implemented during the RI sampling and analysis. The objective of the QAP is to ensure that data are of adequate quality for their intended use. Standard Operating Procedures (SOPs) have been developed as part of the QAP and are incorporated by reference in this FSP.

A site-wide Health and Safety Plan (HASP) (Chino, 1997b, ARCADIS, 2006) has also been developed for the Chino field activities. Personnel performing the field tasks outlined in this FSP will review the HASP prior to initiating on-site work. The sampling activities are to be conducted in accordance with both the QAP and HASP.

Chino will collect splits or duplicates of samples collected as part of this FSP. Chino will provide NMED with at least seven working days advance notice of intended sample collection dates whenever possible, and in no case less than 72 hours prior to sample collection.

A.2 Site Background

The NMED has established pre-FS RAC for the STSIU for arsenic, copper, iron, and cupric ion activity (pCu^{2+} , herein referred to as "pCu"). The criteria for remedial action are:

- Arsenic concentrations greater than 27 mg/kg in 0-1 inch depth soils to protect humans;
- 95 upper confidence limit (UCL) on copper concentrations > 1,600 mg/kg in 0-6" depth soils for small ground-feeding birds (SGFB) in an exposure unit;
- Monitoring of exposure units where the 95 UCL on copper concentrations > 1,100 mg/kg but < 1,600 mg/kg in 0-6" depth soils for SGFB;
- Copper concentrations > 5,000 mg/kg in 0-1 inch depth soils to protect humans;

- $pCu \geq 5$ in exposure units with total copper > 327 mg/kg copper in 0-6 inch depth soils to protect vegetated habitat, and
- Iron concentrations > 100,000 mg/kg in 0-1 inch depth soils to protect humans (NMED, 2011).

The FS and Record of Decision (ROD) will be completed consistent with the National Contingency Plan (NCP). Pre-FS RAC are consistent with the use of preliminary remediation goals (PRG) by EPA in the NCP; therefore, new information can be used to refine the Pre-FS RAC and selection of alternatives (§300.430(e)(2)(i) NCP). Final remediation goals will be determined when the remedy is selected.

The FS Proposal provided an evaluation of each criteria, the available data, and recommended additional sampling for copper and pCu. The constituents of concern (COC), copper and pCu, have been sampled across the Chino Mine site to characterize the concentrations for risk assessment purposes (SRK, 2008). Cupric ion activity, calculated as pCu ($-\log[Cu]$), was measured empirically and also estimated by regressing total copper and pH on measured cupric ion activity in upland sites, with the upland regression equation provided in the Site-wide Ecological Risk Assessment (ERA; Newfields 2006). The upland regression equation was used to estimate pCu on all upland soil samples on the site.

The copper SGFB Pre-FS RAC value of 1,600 mg/kg is intended as a 95UCL area-weighted average concentration within an exposure unit, and the exposure unit should be delineated based on habitat as requested by NMED (NMED, 2011). The term "habitat unit" has not been defined for the AOC; therefore, we propose to use the existing Alliance Level vegetation maps in the site wide ERA. We believe that this mapping intensity is appropriate for the evaluation of population-level wildlife habitat for non-critical species for upland exposure units NMED specifically highlighted their concern about exposure units related to drainages, especially those drainages with valued ecological habitat. Therefore, this work plan also addresses application of the Pre-FS RAC for birds to these exposure units.

The ERA discusses protection of the vegetation community for its function as wildlife habitat and range for livestock. Thus, range condition for livestock and wildlife habitat quality will be assessed in areas averaging pCu less than 5 within rangeland polygons used as exposure units (Figure 1). Because destruction of vegetation and reduction in soil stability associated with remediation may do more harm than good in areas with good range and wildlife habitat conditions, the area with pCu less than 5 will be evaluated for these characteristics.

Range condition was assessed at Chino using a variety of methods within polygons of unique soil and vegetation combinations in 1997 (Woodward Clyde, 1997 and unpublished data). Species richness and vegetation cover were assessed to represent wildlife habitat quality in 1999

(Newfields, 2006). The white rain in 2008 increased pCu and possibly improved these vegetation indices (ARCADIS, 2011a). The soil pCu, vegetation, and range assessments proposed herein will be compared to evaluate changes from the results of these earlier studies.

A.3 Sampling Objectives

The soil sampling program is intended to address the following specific sampling objectives:

- Fill in the data gaps in the distribution of total copper and pCu in the STSIU, estimating, as precisely as needed, concentration throughout the STSIU in areas where the levels of constituents are changing from safe levels to potential levels of ecological (total copper and pCu) or human health (copper) concern;
- Develop exposure units whereby the copper SGFB Pre-FS RAC value of 1,600 mg/kg is intended as a 95UCL area-weighted average concentration within an exposure unit, and the exposure unit is delineated based on habitat as requested by NMED (NMED, 2011);
- Determine where upland and drainage habitat differs to the extent where drainage habitat exposure units are necessary to evaluate risk to the small ground feeding bird;
- Fill in data gaps in range condition, cover, and richness to determine if low pCu is affecting vegetation attributes; and
- Collect field quality control samples as specified in the QAP.

The soil sampling and exposure unit field verification program is described in detail in Section A.4 through A.9.

A.4 Data Quality Objectives: Soil Sampling

The data quality objectives (DQO) process was used to define the data needed to meet these five objectives. This section describes the purpose and identifies the steps of the DQO process.

According to the USEPA, the DQO process is a series of planning steps based on the scientific method that is designed to ensure that the type, quantity, and quality of environmental data used in decision-making are appropriate for the intended application (USEPA, 2000). The DQO process includes the following seven steps, which are addressed in this plan:

- 1) State the problem
- 2) Identify the decisions

- 3) Identify the inputs to the decisions
- 4) Define the study boundaries
- 5) Develop a decision rule
- 6) Specify limits on decision errors
- 7) Optimize the design for obtaining data

A4.1 Problem Statement and Decision Criteria Identification

The problem statement is to spatially define the areas requiring remedial action in the STSIU based upon NMED Pre-FS RAC. The Pre-FS RAC are based upon two COCs, copper and pCu that have been sampled across the site (Figures 1 and 2). Specifically these Pre-FS RAC are (1) 95UCL of copper concentrations across an exposure unit with greater than 1,600 mg/kg in 0-6 inch depth soils, (2) copper concentrations greater than 5,000 mg/kg in 0-1 inch soils, and (3) pCu less than 5 in areas with greater than 327 mg/kg copper in 0-6 inch depth soils (NMED, 2011). The boundaries of areas potentially requiring remedial action are based upon these remedial action decision criteria. The challenge is to spatially define the extent of these concentrations of COCs at the pre-FS RAC criteria and at levels just above and below the criteria. A change in a concentration of greater than 300 mg/kg copper or 0.5 pCu can have a large impact on the area that must be evaluated for remediation. Thus, the precision of the data must be high enough to differentiate such changes.

Copper

The pre-FS criteria for copper for protection of the SGFB will be applied to the spatially-weighted 95 UCL concentrations in exposure units. Habitat polygons represented by the vegetation alliance map developed by DBS&A (1999) (and referenced by NewFields (2006)) will serve as habitat units for upland areas (Figure 2). Based upon previous discussion with NMED, however, those habitat polygons do not differentiate high quality habitat along drainage banks which may require different remedial actions than upland habitat. The ephemeral drainage banks are potentially of high value to SGFB because they may have denser woody vegetation than adjacent upland areas. A vegetation map of the STSIU (Figure 2.1-2 in Newfields, 2006,) identifies woodland vegetation alliances that frequently occur in drainages having higher woody density than the other grassland/shrubland alliances, specifically the (1) fluvial forest and shrubland alliance and the (2) alligator-juniper oak woodland alliance. For portions of drainages in the STSIU that fall within these alliances, an evaluation of the woody cover is needed to determine if the banks of these drainages have higher quality habitat than adjacent upland areas. If so, the banks within the woodland alliance will be delineated as a separate exposure unit. Except for one drainage

requested to be sampled by NMED (discussed below), portions of drainages that are outside these alliances, falling in grassland or a shrub-grassland mix upland alliances, and drainages with similar woody density as adjacent upland, will be considered to have habitat the same quality as upland areas and will be part of the adjacent upland exposure unit.

The copper human health RAC will be applied on a point by point basis similar to sampling methods implemented in the STSIU Interim Action Work Plan (IRAWP) (ARCADIS, 2006). Remedial options for the exceedances of the human health RACs will be discussed in more detail in the FS.

pCu

The exposure unit for pCu was not defined by NMED. Chino proposes the exposure unit be the polygon boundaries defined by combinations of different soil and vegetation types. These boundaries were used for rangeland condition analysis in Woodward Clyde (1997) and thus are referred to as "rangeland polygons" (Figure 1). Thirty polygons were preliminarily identified to contain soils with a pCu less than 5 (Figure 1, after removing facility areas or land in other investigation units). The polygons ranged from less than one acre to greater than 859 acres. The polygons boundaries may need to be further split into smaller polygons to account for sharp changes in rangeland condition, particularly in areas not classified for rangeland condition.

A challenge with defining areas for remediation based upon pCu Pre-FS RAC criteria is that in many areas that may have pCu < 5, good rangeland conditions may exist. Soil surface pCu appears to be a poor predictor of rangeland condition based upon previous work, in which large northern areas of fair and good rangeland condition based upon an Observed Apparent Trend (OAT) score were identified where pCu was less than 5 (Figure 3). The OAT score is one quantified measure of rangeland condition measured on the STSIU in 1997 by Woodward Clyde (1997) and will be used to assess rangeland conditions in areas with pCu < 5. The OAT method is a rapid assessment technique promoted by the Bureau of Land Management (BLM) and Nation Resources Conservation Service (NRCS) whereby the investigator walks through a defined area and visually estimates scores. The method was used to estimate "apparent" trend in rangeland condition without sampling more than one time period. Woodward Clyde (1997) prepared a sampling plan but not a report summarizing their results. However, the datasheets with their results are available. OAT scores were measured in the rangeland polygons, shown in Figure 1 and 3 in 1997 using criteria in Table 1. A high score represents good rangeland condition. The cutoff for fair to good rangeland (referred to as static to upward in observed trend scores) varies depending on the area. For example, BLM Environmental Impact Statement, Drewsey Resource (BLM, 1984) Area in Oregon used 17 as the cutoff, which was also used by NRCS in Wyoming. The cutoff was determined for Chino by evaluating other rangeland condition sampling results measured on soil stability and plant distribution in 1997 in these same areas (see worksheet in Appendix B of Woodward Clyde 1997) which produced preliminary rangeland classifications ranging from Excellent, Good, Fair, to

Poor. Comparing the OAT score to these classifications for rangeland polygons that potentially have $pCu < 5$ in Table 2 suggested ≥ 22 is mostly fair to good rangeland condition.

The sampling effort of the 1997 study was too low at too coarse of a resolution to assess effects to rangeland condition within the $pCu < 5$ contour. Therefore, additional sampling is proposed in this document.

The destruction of the existing vegetation and inevitable increase in soil erosion associated with remediation of good condition rangeland could lead to a loss of environmental benefit. The assumption of loss of environmental benefit is based on the likely amount of time required for the ecosystem to recover after remedial disturbance. For fair to good range, Chino expect these systems to require 1 to 2 decades to regain an equivalent level of function assuming that soil loss is minimal. The inherent climatic variability in this region complicates the predictability of the response and likelihood of near term success. Furthermore, we anticipate that range conditions have improved since 1997 following cessation of smelter activities in 2003 and the white rain event in 2008. Therefore, Chino proposes the decision to remediate areas with $pCu < 5$ be based upon consideration of the current range condition and habitat quality.

Past grazing management affects the amount and composition of vegetation independent of chemical stressors due to historical mineral processing. In New Mexico, grazing can depress vegetation cover levels by up to 39% (Gamougoun et al., 1984, Wertz and Wood, 1986) which can result in poor to fair rangeland condition. The impacts of past grazing practices are compounded on soils with inherent productivity limitations. Many of the soils in the STSIU have limitations associated with high clay contents and restricted thickness over bedrock or indurated caliche layers (SCS, 1983). The combined effects of these conditions are seen at Chino on the rangeland to the east of the tailing impoundments. Some of these areas had OAT scores < 22 where pCu was > 5 (Figure 3), a result of moderate to heavy grazing over the last 100 years on areas with marginal soils. A "fair" rangeland condition, which is 25 to 50 percent of theoretical optimum for the soil type and slope, is consistent with what would be expected of a system exposed to over 100 years of grazing without other stressors such as copper and is consistent with the range of foliar cover observed within the area with $pCu < 5$ (SCS, 1976). Similarly, wildlife habitat is classified as fair to poor throughout Grant County (SCS, 1983).

Areas with $pCu < 5$ and an OAT score of less than 22 would be evaluated for remedial alternatives. In contrast, areas with $pCu < 5$ and an OAT score of greater than or equal to 22 would not be further evaluated for remedial alternatives because an OAT score of 22 or greater represents a rangeland condition of mostly fair to good. The map of OAT scores (Figure 3) will be updated, using the methodology in Section A6.4 and A8.3, to confirm current conditions to assess trends from 1997. Evaluation of rangeland using OAT scores is proposed but other rangeland measures may be proposed if they can be detected more easily using remote sensing.

While there are a number of 1997 rangeland condition polygons that cover the $pCu < 5$ area, little is known of the wildlife habitat quality in this area based upon the indicators relied upon in the ERA (NewFields, 2006). Currently, only one ERA sample falls within the current estimated $pCu < 5$ contour zone (Figure 3). Therefore, in addition to evaluating OAT scores, Chino proposes to create percent cover and richness maps in the $pCu < 5$ area to update knowledge of wildlife habitat quality in this area. Remediation for pCu also will be assessed against the reclamation requirements of New Mexico Energy, Mineral and Natural Resources Department's Mining and Minerals Division (MMD), which provides for slightly different thresholds for richness and cover compared to the ERA but are more appropriate for an analysis of remedial alternatives in the FS (DBS&A, 1999). The adequacy of wildlife habitat in ungrazed areas will be defined as acceptable if cover is $\geq 32\%$, and richness is ≥ 8 , in accordance with MMD guidance and revegetation success guidelines developed for Chino, when climatic conditions are relatively similar to conditions of the reference plots used to assign these criteria (DBS&A, 1999). Areas with a substantial amount of rock outcrop would be required to meet the total canopy cover only after first removing the rock outcrop. Because grazing is excluded from the reference areas used to demonstrate reclamation success, a grazed reference area east of Lampbright Draw with little impact from the smelter will be found to represent reference areas for cover and richness of grazed areas.

The decision criteria for remediation would be to identify rangeland polygons with poor (OAT < 22) rangeland condition or that have poor richness and cover (as defined above) and a $pCu < 5$. These polygons will be evaluated for a remedial alternative to comply with the pCu Pre-FS RAC.

A4.2 Decision Inputs

Based upon the discussion presented above under Section A4.1, there are three decisions that will be addressed by the FSP:

1. Are the existing data sufficient to define the current nature and extent of the COCs of surface soil in the general range of the pre-FS RAC criteria?

Figures 1 and 2 show the locations of the samples used to develop the current understanding for pCu and copper distributions in the STSIU. The pCu map (Figure 1) shows locations and concentration classes of soil data collected in 2009 and 2010 to evaluate and monitor pH and pCu changes in the soil following the white rain event in January 2008 (ARCADIS US, Inc. 2011a). The map also includes locations where pCu was sampled during the insect bioaccumulation study (ARCADIS, 2010b). This map only includes data collected after the white rain event because that event altered the soil pH and thus changed the pCu . In contrast, the copper map (Figure 2) is not limited to recent data as the white rain is not expected to have changed the copper concentrations. That map is based upon soil data collected from 1995 to 2010 and includes data from the following

reports: Chino, 1995; ARCADIS, 2001; NewFields, 2006, 2008; SRK, 2008; ARCADIS, 2009; ARCADIS, 2010a; ARCADIS, 2010b; ARCADIS, 2011a; ARCADIS, 2011b.

Not all samples were collected at 0-6 inch bgs. The concentrations of samples at 0-1 inch bgs were multiplied by 0.7 to represent the 0-6 inch bgs based upon the finding that the ratio of 0-6 inch to 0-1 inch depth strata for copper is 0.7 (median of 37 co-located samples, Table 3) in soils without deposits of windblown tailings. For soils in areas with windblown tailings, the multiplier was 1.5 (median of 7 co-located samples, Table 3). These median ratios were chosen after the average and median ratio, and slope of the regression of a plot of 0-1 inch data against 0-6 inch data (where the slope is essentially a ratio) were compared (Figure 4). The slope of the regression had the lowest value and the median and average ratios for copper were very similar. The median was selected as best because, unlike the regression slope, it was not strongly influenced by the two highest data values, was more conservative than the regression slope, and best represented central tendency because the ratio data were not normally distributed (Shapiro Wilk test, $P < 0.01$). For sites in windblown tailings, where the tailings have low copper, the ratio flips so that the 0-1 inch stratum has lower copper than the 0-6 inch stratum on average. The median was the most conservative method for these data and was selected to be consistent with the method chosen for areas outside the tailings.

The two maps (Figures 1 and 2) show that in some areas sampling was quite dense and the data are sufficient to spatially model the extent of the COCs with the precision desired, but in other areas, data gaps exist, making the extent uncertain. Soil samples will be taken in these data gap areas to ensure good sample coverage across the area of uncertainty (Figures 5 and 6) and will be analyzed using methods discussed in Section A8.

2. Are the existing data sufficient to define the exposure units?

The vegetation alliance map, developed by DSB&A (2000) using > 350 sampled areas and 1:18000 black and white aerial photo interpretation (section 3 in DSB&A, 2000), is considered adequate for defining general vegetation boundaries and for defining habitat units for SGFB exposure in the upland area. Table 4 shows the polygons that currently have at least one sample with copper exceeding the pre-FS RAC. The ephemeral drainage exposure units for copper are not yet defined. Maps of woody cover classes will be developed using aerial photographs and remote sensing with field verification along drainages in woodland alliances to define these exposure units. Exposure units with significantly higher woody vegetation than adjacent upland will be delineated.

As discussed above, the exposure units for pCu are proposed to be the rangeland polygons. These polygons are shown on Figure 1. The adequacy of the polygon boundaries will be assessed through review of aerial photos, remote sensing and field verification and they

will be updated and modified as necessary. Specifically, any sharp changes in range or wildlife condition observed on the images that can be delineated as an obvious boundary will be identified and the polygon further split based upon that boundary.

3. Are the existing data sufficient to define the current nature and extent of rangeland condition and wildlife habitat quality in areas with $pCu < 5$?

Figure 3 shows the polygons classified for rangeland condition (Woodward Clyde, 1997, and unpublished 1997 data) and the one ERA location where richness and cover were sampled on a 50-m transect (Newfields, 2006) within the current estimated contour with $pCu < 5$. Based upon these figures, there are data gaps in rangeland condition, cover, and richness in key areas. Sampling to address these areas is discussed further below.

A4.3 Boundary, Decision Rule, and Limits on Decision Errors

The boundary for defining the spatial extent of the COCs is the STSIU boundary. Other operational areas, private property, or investigation units are not included. At the conclusion of these sampling efforts, contours for the COCs of 0.5 pCu intervals and 300 mg/kg total copper intervals will be developed within the STSIU using an interpolation routine in ARCGIS.

For total copper, if an exposure unit contains copper concentrations greater than or equal to the pre-FS RAC for SGFB (1,100 mg/kg), a spatially-weighted 95UCL of the copper concentrations will be calculated for the given exposure unit. All exposure units with a spatially-weighted 95 UCL greater than the RAC criteria will be evaluated for remedial alternatives in the FS Report. If an exposure unit does not contain a copper result greater than the 1,100 mg/kg RAC, it will not be considered further in the FS. Exposure units exceeding the 1,600 mg/kg RAC will be further evaluated in the FS. If there are exposure units with copper 95UCLs greater than 1,100 mg/kg but less than 1,600 mg/kg, those areas will have biotic and/or abiotic media monitored to evaluate if risk to small ground feeding birds as requested by NMED (2011).

For total copper, if a given area contains copper greater than the 5,000 mg/kg human health RAC, and does not overlap with proposed borrow areas, this area will be evaluated using the methods outlined in the STSIU IRAWP (ARCADIS, 2005). An engineered drawing for borrow areas will be submitted with the FS Report. Any samples that exceed the 5,000 mg/kg RAC will be considered for remediation in the FS report.

For pCu , if an area's rangeland condition is determined to be fair to good ($OAT \geq 22$) and wildlife habitat is acceptable, the area will not be considered for remediation and will not be discussed in the FS Report. Acceptable wildlife habitat for ungrazed areas will be defined as having cover $\geq 32\%$ and plant species richness ≥ 8 , in accordance with MMD guidance and revegetation success guidelines developed for Chino (DBS&A, 1999), assuming climatic conditions are relatively

similar to conditions of the reference plots used to assign these criteria (DBS&A 1999). Grazed areas will be defined as having at least as much cover and as good or better species richness as the reference plot to the east of Lampbright Draw, which will be a grazed reference plot that was not impacted by mining operations. All areas with rangeland or wildlife habitat condition as described above will be identified, using the methods in Section A8.3, and their respective pCu values will be compared to the RAC. If an area with poor rangeland/wildlife condition and contains a pCu contour < 5 based on a pCu kriged map, it will be retained for assessment of remedial alternatives in the FS Report. For areas with pCu < 5 that are classified as good to fair or have acceptable wildlife habitat, Chino will propose monitoring or validation to confirm the rangeland classification.

The concentrations on the site range from 1 to 10 s.u. for pCu and from 30 to 25,000 mg/kg for total copper. The consequences of decision errors (incorrect classification of an area) of the magnitude of one contour interval are low at pCu concentrations < 4 and > 7 , and at copper concentrations < 800 and $> 1,900$ mg/kg. Consequences of errors at concentrations between these values that encompass the RAC threshold are of more concern. When differentiating between an area at the RAC threshold and above, the acceptable error of identifying an area to be remediated that did not need to be (false positive, Type I error) is 10% (90% confidence different from safe area) and for omitting an area that needs to be remediated (false negative, Type II error) is 20% (80% power to detect a difference).

Accuracy of the remote sensing maps delineating good and poor condition rangeland and acceptable and unacceptable wildlife habitat will be set to 70% correct classification using jackknife cross-validation (sample being predicted is removed from calibration dataset to develop the model). A level of 80% is desirable for well-defined remote sensing methods (ESRI, 1994) but may not be attainable given the high, often undetectable small-scale variability that affects rangeland condition. For rangeland condition and species richness/cover mapping, the variables mapped (for example, fair-good = $OAT \geq 22$, and poor = $OAT < 22$ for rangeland map) have two classes that will be evaluated for accuracy. Errors of omission will be instances where a "fair-good" condition is classified as "poor" and errors of commission are where "poor" is classified as "fair-good". In general, it is desirable to make the rates of these errors approximately equal. But to be conservative, the focus will be on finding all areas of poor condition even at the expense of missing some areas of fair-good condition. The goal will be to attain no more than 15% errors of commission. If the remote sensing data are inadequate at differentiating these two classes for OAT scores and species diversity, then the two classes of vegetation cover (e.g., good if $\geq 32\%$, poor if $< 32\%$ for ungrazed areas), may be the main criteria used to screen areas with pCu < 5 for remediation. Vegetation cover may be easier to identify using remote sensing.

A4.4 Optimal Design for Obtaining Data

Below are sampling designs for pCu for plants (Figure 5) and total copper for SGFB (Figure 6) and human receptors.

Plant RAC Sampling

pCu Sampling Design

The Site Wide BERA indicated that when pCu < 5, there is a significant reduction in richness and canopy cover, and key uncertainties were noted in the report including potential affects of grazing. Figure 5 shows the post-white rain (2009 and 2010) locations that have pCu of 4, 5, and 6 that bound this threshold. A zone of uncertainty was established around these points. The delineation of the zone was made large enough to include areas within the pre-white rain contour of pCu <5 (ARCADIS, 2010a)). Additionally, the spatial extent of the 2009 and 2010 data was expanded outward in areas potentially near the threshold RAC criteria, which was in the northwestern edge of the STSIU. The area of uncertainty selected is large given the spatial (range of 0.02 to 0.9 in 30 x 30 m plot), temporal (range of 0.3 to 2.3 from 2009 to 2010 plus changes from pre- to post-white rain), and laboratory (0.2 to 0.4 error on duplicates) variability in estimating pCu. Thirty-seven samples already exist within the area of uncertainty with a standard deviation in pCu of 1.07. The minimum detectable change of interest (delta) between sets of locations to differentiate the pCu 5 and 6 zones was set to 0.5 pCu units. The confidence was set to 90% and the power to 80%. The pCu values in the area of uncertainty were normally distributed (Shapiro-Wilk test, P = 0.65). However, because the cupric ion concentrations are not normally distributed, a non-parametric method was used for differentiating pCu zones. The minimum number of samples required (N) was estimated based on guidance in USEPA (2010) using the following one-sided 2-sample Wilcoxon Mann-Whitney test sample size equation:

$$N \geq 1.16 [2 (Z_{1-\alpha} + Z_{1-\beta})^2 (SD/\Delta)^2 + Z_{1-\alpha}^2/4]$$

Where:

$Z_{1-\alpha}$ = 1.282 corresponding to a confidence level of 90%

$Z_{1-\beta}$ = 0.842 corresponding to a power of 80%

SD = standard deviation

Δ = 0.5 = minimum detectable difference between two medians

The minimum sample size needed to discern a difference of 0.5 within the area of uncertainty is 48, or, an additional 11 randomly placed samples, given 37 samples are already in the zone (Table 4). However, this estimate ignores the gradient in copper across the site. Given there is a gradient, an additional requirement of the study design is to have good spatial coverage of the area. Good spatial coverage cannot be obtained with 11 samples because some of the existing 37 samples are clustered and do not cover the large data gaps. Analyzing the available data, it appears that pCu can vary by one s.u. within an interval as narrow as 1,000 m in width (Figure 1) and should have at least two samples across the zone width (with 500 m spacing) to be able to delineate the pCu zone. Thus, to obtain good coverage of the areas with sampling gaps, this number was increased to 40 samples. An additional 40 samples (blue triangles in Figure 5) were located randomly throughout the area of uncertainty in locations that avoided slopes too steep to sample ($>22\%$, Figure 7) and avoided being placed too close to another sample (within 250 m). To ensure good coverage across the area of uncertainty, the samples were stratified such that 40 samples increased coverage with in the area of concern. The proposed sample locations are shown in Figure 5. Each of the samples at the 40 locations will be a composite of 5 subsamples taken within a 50 m by 50 m area at the corners and center (sieved at $< 2\text{mm}$). The soil sample depth will be 0-6 inches below ground surface (bgs). The coordinates for the pCu sample locations will be summarized in Table 6 upon NMED approval and finalization of the STSIU FS Proposal.

Vegetation Sampling Design

The threshold of concern for rangeland condition was selected as an OAT score of < 22 . OAT scores were collected in the STSIU in 1997 (Woodward Clyde, 1997) and incorporate ratings for plant characteristics (vigor of desirable plants, seedling establishment, and litter) and soil characteristics (pedestals, crusting, and gullyng, Table 1) relative to a nearby reference area that has similar soil type, slope, and management history.

Figure 3 shows the current locations of 30 polygons with estimated OAT scores and at least one sample with $\text{pCu} < 5$ in the STSIU or a potential for < 5 pCu and Table 2 lists the OAT scores estimated for each polygon. As discussed above, for remediation purposes, an OAT score of < 22 is considered poor rangeland (classified as poor relative to a reference area) that should be remediated and ≥ 22 is good rangeland that should be protected from remediation. The scores for these polygons need to be verified in the field by walking a 200-m field transect placed in a representative location in each rangeland polygon and recording the OAT score using the criteria in Table 1.

New data will be collected at 15 locations in rangeland polygons that potentially have soils with $\text{pCu} < 5$ (Figure 3) and represent a range of OAT scores (based upon 1997 data) across the current mapped polygons. These 15 locations provide good representation of the areas near the decision boundary of 22. The data will be collected to develop a correlation with the 1997 data. If the correlation is strong ($r \geq 0.8$), the current OAT map will be used, although some polygons may be

split if sharp boundaries in rangeland or wildlife condition are observed within polygons on aerial photos or spectral images.

If the 1997 OAT scores cannot be correlated directly to the new OAT scores (correlation < 0.8), the 1997 OAT score data will be updated using remote sensing, calibrated to the data from new locations. The relationship between spectral image data (from a remotely sensed image) and the OAT score will be calibrated using the 15 sampling points discussed above. To update the map, the field transects will be located on a satellite image taken over the site in August or September 2011. The map will be developed by using the relationship between image data and OAT scores to predict OAT scores for every 200 m section in areas with $pCu < 5$. These pixel values will be averaged within each rangeland polygon to obtain final OAT score estimates. Then each polygon will be classified as good-fair (≥ 22 OAT score) or poor.

An effort will be made to ensure ends of the OAT spectrum (very poor and excellent) are captured. If a first sampling session produces high standard errors or root mean square errors that lead to poor predictions relative to observed data, or if the area with $pCu < 5$ and soil copper > 327 mg/kg turns out to be larger or distributed differently than current data supports, then a second sampling event may be required to adequately capture the range of OAT scores in areas with low pCu on the site.

The approach to developing remotely sensed maps of wildlife habitat quality will be similar to the rangeland condition mapping process. The same polygons and field locations sampled for OAT scores will be sampled for plant species richness and percent cover (Figure 3), following methods used in the amendment plots (ARCADIS 2011b) and DBS&A (1999) to evaluate revegetation success. A relationship between cover and richness with spectral data will be developed, if possible, and verified with a subset of the field data. That relationship will be used to classify the cover and richness of the entire area of rangeland polygons with $pCu < 5$. Just as the rangeland map will be binned into good-fair versus poor rangeland condition, the final map for cover and richness will be binned into acceptable and unacceptable wildlife habitat quality (e.g., using $\geq 32\%$ for cover and > 8 species for richness for ungrazed areas and reference criteria for grazed areas) as the thresholds for remediation decisions. In addition to the above computational measures, the boundaries of polygons of acceptable versus unacceptable wildlife habitat are tentatively the rangeland polygons but will be evaluated for adequacy in classifying cover and richness by discerning if any sharp changes in cover or richness are visually obvious on photos or images. If such changes can be delineated, the polygons will be split into smaller polygons along such delineated boundaries. Additionally, once the boundaries between fair-good and poor are delineated, three or four of these boundaries will be driven or walked to verify that the rangeland difference is visible between the units.

Small Ground Feeding Bird RAC Sampling

Upland Copper Sampling Design

Unlike pCu for which STSIU had only had 61 samples representing current conditions (post-white rain), 294 copper samples were available to estimate copper distributions and, thus, the sampling design focuses on filling gaps in the spatial data in the current copper dataset needed for a good interpolation model. The area of uncertainty (red polygon in Figure 6) includes locations with concentrations ranging from 800 to 2,700 mg/kg. There are 88 existing samples within this area, with a standard deviation of 1,088. The minimum detectable change of interest (delta) was set to 300 mg/kg because the width of Cu contour bands averages about 300 m band, which is a narrow and higher resolution is unlikely given the spatial variability of Cu. Also, a 300 mg/kg increase on the pre-FS RAC has a small effect on the risk to SGFB (shown by a hazard quotient increase from 1 to 1.02). The confidence for detecting this difference was set to 90% and the power to 80%. Because copper was not normally distributed (Shapiro-Wilk test, $P < 0.001$), the one-sided 2-sample Wilcoxon Mann-Whitney test sample size equation was used to determine sample size. When applied to copper parameters, a minimum sample size of 139 was required, or an additional 41 samples if the copper gradient across the site is ignored (Table 4). However, a gradient of copper from the smelter emissions exists and thus good spatial coverage across the gradient in the area of uncertainty is required, which can be accomplished with transects if XRF sampling is used.

Nine transects perpendicular to the estimated copper gradient are proposed in areas where samples are few and terrain not too steep ($<22\%$ slope) and will be driven or walked, sampling the surface soil (sieved to <2 mm) every 200 m using XRF in a direction outward from the smelter (Figure 6). Assuming samples will be spaced every 200 m on each transect, a total of 57 samples will be collected over all transects (blue and purple triangles in Figure 6), more than the 41 minimum sample number required. Some southern areas with data gaps in the area of uncertainty soon will have copper distribution characterized by XRF as part of the reclamation program or will become borrow areas for reclamation work and thus will not be sampled again for this plan.

For confirmation of the XRF results, nine 0-6 inch bgs samples in areas estimated to range from low to high copper concentrations (purple triangles in Figure-6) will be sent to the laboratory to estimate copper concentration. Nine samples were selected for joint analysis as this number more than satisfies the required sample size to provide a significant relationship ($p < 0.05$) between laboratory and XRF results when the coefficient of determination is defined as a $r^2 > 0.8$. The XRF results at the same locations as these samples will be regressed on the laboratory results to create a regression equation to convert XRF data to 0-6 inch bgs data. The relationship between laboratory and XRF results will be determined using USEPA Method 6200. The confirmation samples will be composites of 5 subsamples in a 50 x 50 m area. The coordinates for the sample locations for copper are in Table 5.

Drainage Copper Sampling Design

The type of remediation required may differ along the banks of ephemeral drainages as compared to upland areas because of the possibility of denser woody vegetation providing higher-quality bird habitat. An evaluation of the woody cover is needed to determine if the banks of STSIU drainages in woodland alliances (Figure 8) have higher quality habitat than adjacent upland areas. Percent cover of woody vegetation can be assessed using remote sensing data. For example, the normalized difference vegetation index (NDVI) is high in dense, healthy, growing vegetation and previous work has shown NDVI has a unique signature for dense woody versus non-woody vegetation. A relationship developed between NDVI or near-infrared spectrum data and ground-collected data on woody vegetation percent cover in areas of interest will be used to estimate percent cover by woody plants.

Figure 8 shows locations of banks and adjacent upland areas that will be assessed and compared for woody cover. These drainage banks are within vegetation alliances that have bottomland woody cover. Because of NMED's request, an additional drainage was added that is in an upland vegetation alliance (Figure 8).

The field data collected to calibrate the relationship between spectral signatures or NDVI and woody cover, will consist of estimates of percent woody cover taken along one 100-m transect along the bank parallel to the drainage and one 100-m transect in the nearby upland (at least 500 m away) at each sampling point in Figure 8. The line intercept method will be used, measuring the percent of the transect intersecting woody vegetation canopy. The upland transect will be parallel to the bank transect.

Because field cover probably can generally only be estimated to within 10% accuracy with consistency for line intercept methods, cover modeled to within about 10 percentage points of ground reference will be considered "correct" in the accuracy assessment. The accuracy requirement must be at least 70% of the transects are correctly classified to use the remotely sensed results to compare upland and drainage vegetation (using jackknife cross-validation). If such accuracy is obtained, the average cover of the drainage area must be at least 25 percentage points different from the upland to be considered different. If the map does not meet the accuracy requirement, the field data will be statistically compared or supplemented with more field work if the field sample sizes are inadequate.

The canopy cover will be evaluated for at least a 25% difference between the upland and bank habitats quantified by remote sensing. If they differ by that amount, the banks will become exposure units separate from upland exposure units.

During the field sampling of locations shown in Figure 8, Chino will take 12 soil samples from the same locations sampled for vegetation on the banks (composite of 3 on a 50-m transect parallel to the channel). The soil samples will be taken from the start, middle, and end of the transect at a depth of 0-6 inches bgs and sieved to > 2-mm. These bank samples will be used to determine a spatially weighted 95UCL on copper concentrations for a given drainage area. If the 95UCL for the drainage area is > 1,600 mg/kg the area will be evaluated further for remedial alternatives in the FS. If the 95UCL is greater than 1100, the area will be monitored. The coordinates for these sample locations are shown on Table 6

Human Health RAC Sampling

Copper Sampling Design

As seen in Figure 2, the copper concentrations greater than 5,000 mg/kg are concentrated to the east and southeast of the former smelter. This area, is currently proposed to serve as a source of borrow material for closure of Lake One. After closure of Lake One, Chino will identify the extent of excavation area and document that copper in soil at a concentration greater than 5,000 mg/kg was removed. As stated in the STSIU IRAWP, the nature of the historical distribution of copper in these areas was via air dispersion in a predictable pattern decreasing in concentration from the source. Due to the nature of the disposition, a grid sample pattern is appropriate for the confirmation sampling. The grid size will be determined by calculating the needed sample size using the equation in IRAWP and the overall excavation area.

A.5 Sample Designation

In addition to location codes, individual samples are to be designated by a unique sample number in accordance with the site-wide sample numbering scheme specified in SOP-1, Field Document Control. Sampling information, field measurements, and other field data will be recorded in a field notebook in accordance with the procedures specified in SOP-1 and in SOP-2, "Field Logbook" and "Field Data Sheets", respectively.

A.6 Sample Equipment and Procedures

In accordance with the objectives of the QAP, SOPs will be implemented during field activities to maximize consistency in field activities. The SOPs are in Appendix B of the RI QAP (Chino, 1997).

A6.1 General SOPs

The following general SOPs will be implemented during this FSP:

- Field Document Control (SOP-1) – Presents the sample numbering scheme to be implemented for samples collected in the STSIU. SOP-1 also presents procedures for recording information that is relevant to field operations;
- Field Logbook and Field Sample Data Sheets (SOP-2) – Identifies minimum entries to be included in field logbook or field sample data sheets. Includes procedures for taking photographs and labeling them;
- Field Quality Control (SOP-3) – Describes field QC measures and QC samples, including sample preparation and collection frequency;
- Sample Custody Procedures (SOP-4) – Establishes Chain-of-Custody procedures to be followed during field sample collection and transfer to the laboratory. Included are examples of a sample label, field sample data sheets, and a Chain-of-Custody record;
- Packaging and Shipping of Environmental Sample Containers (SOP-5) – Lists procedures for preparation and shipment of field samples sent to the analytical laboratory. Included is an example of a custody seal to be attached to each shipment;
- Decontamination of Equipment Used to Sample Soil and Water (SOP-6) – Presents the decontamination requirements for non-disposable sampling equipment. Included is a list of recommended equipment to be used for decontamination. Disposable equipment will be used to the extent possible to reduce opportunities for cross-contamination and decrease the level of effort for decontamination. For reusable field equipment, decontamination is required to prevent cross-contamination of samples from different sampling locations;
- Requesting Environmental Laboratory Services (SOP-7) – Provided in this SOP is a form for requesting analyses by the contracted laboratory, including number of samples, proposed schedule and designated contact; and
- Sampling, Preservation and Containerization (SOP-14) – Summarizes the required sample volume, container type, preservation and holding time.

A6.2 Soil SOPs

SOP-22 “Surface Soil Sampling” will be followed for field sampling procedures. Each soil sample will be a composite of five sub-samples taken over a sample interval of six inches in sample depth as measured from the ground surface. The five sub-samples will be sampled over a 50 x 50 m area (rather than 20 feet in the SOP) to reduce microscale variability and the locations will be representative of the area.

A description of the composition of each soil sample and other relevant information will be noted in the field logbook and/or field sample data sheets. In accordance with SOP-3 "Field Quality Control", field QC samples (one per 10 samples) and rinsate blanks (one per 20 samples) will be collected as part of the sampling program. These blind field duplicate samples and rinsate blanks will be submitted for laboratory analyses.

SOP-23 and -23a "XRF on Site Measurement" will be followed for field XRF calibration and sampling procedures.

A6.3 Survey of Sample Locations

All sample locations will be surveyed for coordinate position and elevation using the Global Positioning System (GPS).

A6.4 Vegetation SOPs

Procedures for sampling vegetation for rangeland condition will follow the OAT score protocol outlined in Section A4.4, pCu sampling design. Methods for sampling vegetation for richness and cover will follow those used for the amendment plots (ARCADIS 2011b) using DBS&A (1999) sampling protocol. Methods for sampling woody cover will follow the protocol outlined in Section 4.4, drainage copper sampling design. Photographs will be taken at all sample locations.

At all 15 sampling points shown on Figure 3, each within one of 15 rangeland polygons and within the approximate pCu <5 contour, a 200-m transect will be walked and an OAT score recorded using the worksheet in Table 1. Before sampling the transect, the polygon will be walked as they did in 1997 to evaluate the criteria used in developing the OAT score for the entire polygon. The score on the 200-m transect will only be used to correlate to the corresponding pixel on the remote sensing map. The field investigators from NMED and Chino will jointly decide on the scores and will not be able to refer to the 1997 results to avoid biasing their results.

A.7 Sample Handling and Analysis

Sample bottle requirements for rinsate, holding times, and preservation techniques are listed in SOP-14 "Sampling, Containerization and Preservation", and are consistent with the laboratory requirements. Rinsate samples for chemical analysis will be placed into media-appropriate bottles and stored in ice filled coolers until delivery to the laboratory. Soil samples will be sealed in plastic bags and shipped in coolers. Samples will be handled and shipped in accordance with SOP-4 "Sample Custody Procedures" and SOP-5 "Packaging and Shipping of Environmental Sample Containers."

Table 4-2 in Section 4.2 of the RI Proposal presents the analytical program for soils. Metals will be analyzed using Contract Laboratory Program (CLP) analytical methods and pH by EPA Method 9045A as specified in Table 4-1 of the Quality Assurance Plan. Analytical data will be obtained in accordance with the QA/QC provisions and using the laboratory QC samples specified in the QAP.

Each soil sample will be made up of five sub-samples taken on a 50 m by 50 m area. All 30 composited soil samples collected to estimate pCu will be tested for pH and total copper after the soils have been sieved to <2 mm. The soil samples will be sent to the laboratory for pH paste analysis using deionized water and total copper analysis by dry weight using ICP (EPA 6010) with a method detection limit of 1 mg/kg. Two rinsate samples and three soil duplicate samples will be collected and analyzed for Copper and pH. The five sets of five subsamples (grab samples) will be analyzed for Copper and pH in the same manner.

For copper, the 9 composite samples collected to obtain a conversion factor for the surface soil XRF concentrations to 0-6 inch soil concentrations of copper will be sent to the laboratory for copper analysis by dry weight after sieving to < 2 mm. Analysis will use ICP (EPA 6010) with a method detection limit of 1 mg/kg. One duplicate and one rinsate sample will be analyzed for total copper.

A.8 Processing of Results

A8.1 Spatial Interpolation of pCu

Samples collected as part of this effort will be added to existing point samples representative of current conditions to create an updated, more precise understanding of pCu concentration and potential exceedances of the Pre-FS RAC. After field sampling and laboratory analysis, the data will be input into ARCGIS and Kriging will be used to create a continuous pixel surface of concentrations to predict pCu in unsampled areas. The more nearby sampling points available to inform the estimated concentration of a given pixel, the less uncertainty is associated with the final interpolated map. The estimated pCu concentration represented by the area within the Kriged boundary of pCu < 5 contour line will be used to screen exposure unit polygons. Polygons that intersect the pCu < 5 contour will be evaluated for rangeland and wildlife habitat condition and addressed in the FS. If they are screened out based on good-fair rangeland or acceptable wildlife habitat conditions, an evaluation of the sampling adequacy for pCu and rangeland in the polygons will be made to ensure this conclusion is statistically supported (considering the kriging model error and remote sensing accuracy in that area). If sampling is inadequate, additional sampling may be required. Similarly, some polygons that were not screened out may require additional sampling for the same reasons.

A8.2 Spatial Interpolation to Define 95 UCL Copper in Exposure Units

Figure 8 provides the decision tree that will be used to select the appropriate spatially-weighted averaging method to calculate a 95 UCL of total copper concentration in the exposure units. The interpolation techniques in Figure 8 are discussed in greater detail in USEPA (2004). The spatial interpolation/estimation choices include Thiessen polygons, IDW, or kriging. Factors that will affect the decision include frequency of detections, spatial autocorrelation, relationship between polygon weights and concentration, exposure concentration relative to RAC, and semivariogram fit. Once the method is selected, the average and 95% confidence interval will be calculated using the method that is appropriate to the distribution of the data (normal, log-normal, gamma, or non-parametric distribution) and spatial averaging method.

A8.3 Evaluation of Remote Sensing for Rangeland and Wildlife Habitat Quality in areas with low pCu

There are several challenges to using remote sensing for rangeland assessment (Freidel et al. 2000). Many of the variables used to assess rangeland such as pedestals and leaf litter may occur at such a microscale they cannot be observed in a remotely sensed pixel. Available imagery includes a pan-sharpened Quickbird satellite image collected in four bands (three visible and near-infrared), with a spatial resolution of half a meter. While this image should provide the necessary spatial resolution, there may still be factors visible on the ground that are not discernible in the imagery. The evaluation, however, will focus on accurate estimate of the binary classification of good-fair vs. poor using sample data to calibrate the classification process. In addition to identifying spectral reflectance differences in species and growth forms, NDVI and its standard deviation, multi-date imagery, and distance from water (stockpounds heavily used by cattle) sometimes are good predictors of rangeland condition that can be evaluated to refine the rangeland classification (Hutchinson and Warren, 1983; Pickup et al., 1994; Freidel et al., 2000; Richie et al., 2008; Mohamed et al., 2011; Vanderpost et al., 2011) and such methods are used in New Mexico (Richie et al., 2008; Mohamed et al., 2011). Remote sensing may provide a better basis for detecting the actual sharp boundaries in rangeland condition through the resolution of reflectance intensity for spectral signatures associated with fair-good versus poor rangeland condition.

The data will be collected to develop a relationship between spectral data on remotely sensed imagery and the OAT score classes of good-fair and poor (Table 2). The spectral relationship will be used to classify the rangeland classes of the entire area of interest. The boundary of polygons will be evaluated, and if necessary, re-defined to the extent practicable using sharp boundaries observed in photos and images. Image segmentation of the pixel data into similar "objects" can also help identify sharp boundaries.

For wildlife habitat quality, a relationship between cover and richness with spectral data will be developed, if possible. That relationship will be used to classify the cover and richness of the exposure units with predicted $pCu < 5$. The final map for each will be binned into acceptable and unacceptable wildlife habitat using aforementioned criteria for cover and richness as the thresholds for acceptable quality habitat. Boundaries of polygons of acceptable versus unacceptable wildlife habitat (rangeland polygons) for cover and richness will be evaluated for adequacy by identifying sharp boundaries on the images.

Unlike percent cover, species richness is a complex problem for remote sensing analysis and may not be feasible. Depending on the species composition present, it may be possible to perform a species-level classification using remote sensing that can be used to assess richness. This classification would be object-based and use Quickbird imagery with high spatial resolution to divide an area into segments. Each segment will represent a single cluster of like species identifiable based upon ground-collected data. The number of such different clusters may provide an index correlated to species richness. If remote sensing is not feasible for species richness, the evaluation will rely upon percent cover.

A8.4 Delineation of Ephemeral Drainage Exposure Units for Copper

Remote sensing of bank vegetation along ephemeral drainages (25' on either side) will focus on the near-infrared portion of the electromagnetic spectrum to assess percent woody cover. A relationship developed between NDVI or near-infrared spectrum data and ground-collected data on woody cover will be used to estimate percent woody cover in unsampled areas (if the two remote sensing and field observations are accurate within 10% cover). The canopy cover from the created remote sensing map of woody cover will be estimated for the entire area of the banks and adjacent uplands, rather than just for a sample (a complete census if the remote sensing map is considered accurate, that is, it passes the 70% accuracy test discussed in Section A.4 under drainage copper sampling). Thus, a minimum detectable difference must be defined and was set at 25% between upland and banks as a reasonable amount to differentiate bird habitat, given measurement errors. Banks significantly different from upland will become exposure units separate from upland exposure units.

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Table 1
Criteria used to score Observed Apparent Trend (OAT)
Freeport-Mcmoran Chino Mines Company
Vanadium, New Mexico
Smelter/Tailings Soils Feasibility Study Proposal

Check appropriate box in each category which best fits area being observed. Points may vary within each category.

| | |
|--|--|
| <input type="checkbox"/> VIGOR (10 points) | Desirable grasses, forbs and shrubs are vigorous, showing good health. These plants have good size, color, and produce abundant herbage. |
| <input type="checkbox"/> (6 points) | Desirable grasses, forbs and shrubs have moderate vigor. They are medium size with fair color, and produce moderate amounts of herbage. Some seed stalks and seed heads are present. |
| <input type="checkbox"/> (2 points) | Desirable grasses, forbs and shrubs have low vigor. They appear unhealthy with small size and poor color. Portions of clumps or entire plants are dead or dying. Seed stalks and seed heads are non-existent, except in protected areas. |
| <input type="checkbox"/> SEEDLINGS (10 points) | There is seedling establishment of desirable grasses, forbs and shrubs. Seedlings are present in open spaces between plants and along edges of soil pedestals. Few seedlings of invader or undesirable plants are present. |
| <input type="checkbox"/> (6 points) | Some seedlings of desirable grasses, forbs and shrubs may or may not be present in open spaces between plants. Some seedlings of invader or undesirable plant species may or may not be present. |
| <input type="checkbox"/> (2 points) | Few if any seedlings of desirable grasses, forbs and shrubs are being established. Seedlings of invader or undesirable plants are present in open spaces between plants. |
| <input type="checkbox"/> SURFACE LITTER (5 points) | Surface litter is accumulating in place. |
| <input type="checkbox"/> (3 points) | Moderate movement of surface litter is apparent and deposited against obstacles. |
| <input type="checkbox"/> (1 point) | Very little surface litter is remaining. |
| <input type="checkbox"/> PEDESTALS (5 points) | There is little visual evidence of pedestalling. Those pedestals present are sloping or rounding and accumulating litter. Desirable forage grasses may be found along edges of pedestals. |
| <input type="checkbox"/> (3 points) | There is moderate pedestalling with no visual evidence of healing or deterioration. Small rock and plant pedestals may be occurring in flow patterns. |
| <input type="checkbox"/> (1 point) | Most rocks and plants are pedestalled. Pedestals are sharp-sided and eroding, often exposing grass roots. |

| | |
|---|---|
| <input type="checkbox"/> SURFACE CRUSTING (5 points) | There is little visual evidence of surface crusting. |
| <input type="checkbox"/> (3 points) | There is moderate surface crusting, with no visual evidence of healing or deterioration. (Note reason for cause) |
| <input type="checkbox"/> (1 point) | Severe surface crusting. (Note reason for cause) |
| <input type="checkbox"/> RILLS AND GULLIES (5 points) | Gullies (including rills) may be present in stable condition, with moderate sloping or rounded sides. Perennials are establishing themselves on bottom and sides of channel. |
| <input type="checkbox"/> (3 points) | Gullies are well developed, with small amounts of active erosion. Some vegetation may be present. |
| <input type="checkbox"/> (1 point) | Sharply incised V-shaped gullies cover most of the area, with most of the gullies actively eroding. Gullies are mostly devoid of perennial plants. They have fresh cutting on the bottom. |
| TOTAL: _____ | |
| FIELD NOTES: | |
| | |

Table 2
Rangeland condition indices and acres measured in rangeland polygons with OAT scores potentially with pCu < 5

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Polygon ID | OAT Score ² | Preliminary Condition ¹ | OAT Score Class | Acres |
|---------------------------|------------------------|------------------------------------|-----------------|-------|
| HE393/394 | 12 | Poor | Poor | 69.2 |
| HE216 | 13 | Poor | Poor | 121.6 |
| HE390 | 14 | Poor | Poor | 54.3 |
| HE314 | 18 | Fair-Poor | Poor | 36.7 |
| HE291 | 21 | Fair | Poor | 288.7 |
| HE292 | 21 | Fair | Poor | 279.4 |
| HE316 | 22 | Fair-Poor | Fair-Good | 122.8 |
| HE315 | 22 | Fair | Fair-Good | 22.9 |
| HE320 | 22 | Poor | Fair-Good | 25.1 |
| HE321 | 22 | Fair | Fair-Good | 60.4 |
| HE395 | 22 | Fair-Poor | Fair-Good | 209.3 |
| HE205 | 22 | Fair | Fair-Good | 858.5 |
| HE187 | 24 | Poor | Fair-Good | 52.7 |
| HE308 | 24 | Fair | Fair-Good | 187.5 |
| HE317 | 24 | Fair | Fair-Good | 43.0 |
| HW112/163 | 26-34 | Fair | Fair-Good | 267.9 |
| HW111/165 | 26-34 | Good-Fair | Fair-Good | 519.2 |
| HW155/160 | 26-34 | Good-Fair | Fair-Good | 349.0 |
| HE533A, HE203/204/205/206 | 27 | NA | Fair-Good | 652.4 |
| HE193 | 27 | Good | Fair-Good | 533.1 |
| HE196B | 27 | Good | Fair-Good | 107.5 |
| HE309 | 27 | Good-Fair | Fair-Good | 42.8 |
| HE186 | 28 | Fair | Fair-Good | 71.4 |
| HE189/191 | 30 | Fair | Fair-Good | 46.0 |
| HE190 | 30 | Fair | Fair-Good | 41.5 |
| HE193B | 32 | Good | Fair-Good | 48.6 |
| HE45A | 32 | Fair | Fair-Good | 133.0 |
| HE196 | 33 | Good | Fair-Good | 89.6 |
| HE192 | 33 | Fair | Fair-Good | 320.4 |
| HE32A | 34 | Good | Fair-Good | 90.7 |

¹Preliminary condition is average of good, fair, and poor rankings for five soil stability criteria, three plant distribution criteria, and three plant recovery criteria (Woodward Clyde, 1997) and is independent of OAT score.

²OAT score is calculated using criteria in Table 1

NA = not available

Table 3
Copper Results Comparison of 0-1 inch and 0-6 inch Samples

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Sample ID | Copper 0-1 inch | Copper 0-6 inch | Ratio of Copper in Site Soil | Ratio of Copper in Tailings Soil |
|------------------------|--------------------|--------------------|---------------------------------|-------------------------------------|
| FID 0 | 538 | 329 | 0.61 | |
| FID 1 | 175 | 143 | 0.82 | |
| FID 2 | 453 | 405 | 0.89 | |
| FID 3 | 377 | 236 | 0.63 | |
| FID 4 | 676 | 599 | 0.89 | |
| FID 6 | 650 | 182 | 0.28 | |
| FID 7 | 192 | 242 | 1.26 | |
| FID 8 | 328 | 430 | | 1.31 |
| FID 10 | 1050 | 1020 | 0.97 | |
| FID 12 | 5580 | 4260 | 0.76 | |
| FID 13 | 1280 | 1970 | | 1.54 |
| FID 15 | 1530 | 1360 | 0.89 | |
| FID 16 | 362 | 512 | | 1.41 |
| FID 17 | 9150 | 4680 | 0.51 | |
| FID 18 | 215 | 326 | | 1.52 |
| FID 20 | 755 | 790 | | 1.05 |
| FID 21 | 153 | 131 | 0.86 | |
| FID 22 | 347 | 285 | 0.82 | |
| FID 23 | 168 | 252 | | 1.50 |
| FID 24 | 222 | 121 | 0.55 | |
| FID 25 | 89 | 66 | 0.74 | |
| FID 26 | 134 | 75 | 0.56 | |
| FID 27 | 322 | 206 | 0.64 | |
| FID 28 | 426 | 348 | 0.82 | |
| FID 30 | 291 | 90 | 0.31 | |
| FID 31 | 294 | 187 | 0.64 | |
| FID 32 | 2250 | 2120 | 0.94 | |
| FID 33 | 785 | 308 | 0.39 | |
| FID 34 | 682 | 209 | 0.31 | |
| FID 35 | 219 | 210 | 0.96 | |
| FID 39 | 590 | 414 | 0.70 | |
| FID 43 | 229 | 466 | 2.03 | 2.03 |
| S77/SS147 | 379 | 267 | 0.70 | |
| S76/SS144 | 449 | 278 | 0.62 | |
| S75/SS140 | 1180 | 940 | 0.80 | |
| S74/SS136 | 783 | 529 | 0.68 | |
| S73/SS133 | 1500 | 1290 | 0.86 | |
| SS131D/SS131S | 454 | 444 | 0.98 | |
| SS129D/SS129S | 315 | 337 | 1.07 | |
| S72/SS126 | 1400 | 1160 | 0.83 | |
| SS124D/SS124S | 1150 | 523 | 0.45 | |
| SS125D/SS125S | 398 | 166 | 0.42 | |
| SS118D/SS118S | 640 | 259 | 0.40 | |
| SS119D/SS119S | 338 | 125 | 0.37 | |
| | | | | |
| median | 437.5 | 327.5 | 0.72 | 1.50 |
| average | 897.6818 | 665.6818 | 0.74 | 1.48 |
| sample size (n) | 44 | 44 | 38 | 7 |
| slope of Cu regression | | | 0.61 | 1.41 |

Note: median ratio chosen as most valid--not influenced by outliers, median is close to 1.0 for pH, so no ratio adjustment required for pH

Table 4
Acreages of vegetation polygons with samples that have Cu > 1600 mg/kg

FREEPORT-MCMORAN CHINO MINES COMPANY
 VANADIUM, NEW MEXICO
 SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Polygon | Number of Samples (in given polygon) | Area (acres) | Copper | |
|---------|---|-----------------|----------------|----------------|
| | | | Min (mg/kg) | Max (mg/kg) |
| 26 | 43 | 762.2 | 224 | 5593 |
| 32 | 54 | 586.2 | 129 | 7350 |
| 120 | 28 | 878.9 | 385.7 | 4046 |
| 6 | 7 | 23.2 | 385.7 | 3115 |
| 100 | 7 | 33.7 | 798 | 5817 |
| 141 | 7 | 9.8 | 798 | 5593 |
| 23 | 26 | 226.1 | 34.1 | 5593 |
| 1 | 3 | 226.1 | 1160 | 3038 |
| 142 | 63 | 5908.1 | 34.1 | 5350 |
| 128 | 2 | 0.3 | 2737 | 4669 |
| 9 | 48 | 359.1 | 62.6333 | 2527 |
| 105 | 10 | 107.4 | 259 | 1764 |

Notes:

mg/kg = milligram per kilogram

Table 5
Statistics calculated on pCu samples within area of
uncertainty to estimate sample size (N)

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Statistic | pCu | Copper |
|------------------|------------|---------------|
| Count | 37 | 88 |
| Mean | 5.166 | 1736.16 |
| StDev | 1.066 | 1094.2 |
| Delta | 0.5 | 300 |
| N >= | 48 | 139 |



LEGEND:

- | | | |
|------------|--------|--|
| pCu | 7 - 8 | Rangeland Polygons (Exposure Unit for pCu) |
| 3 - 4 | 8 - 9 | Town Roads |
| 4 - 5 | 9 - 10 | Major Roads |
| 5 - 6 | >10 | Smelter Tailing Boundary |
| 6 - 7 | | City Areas |

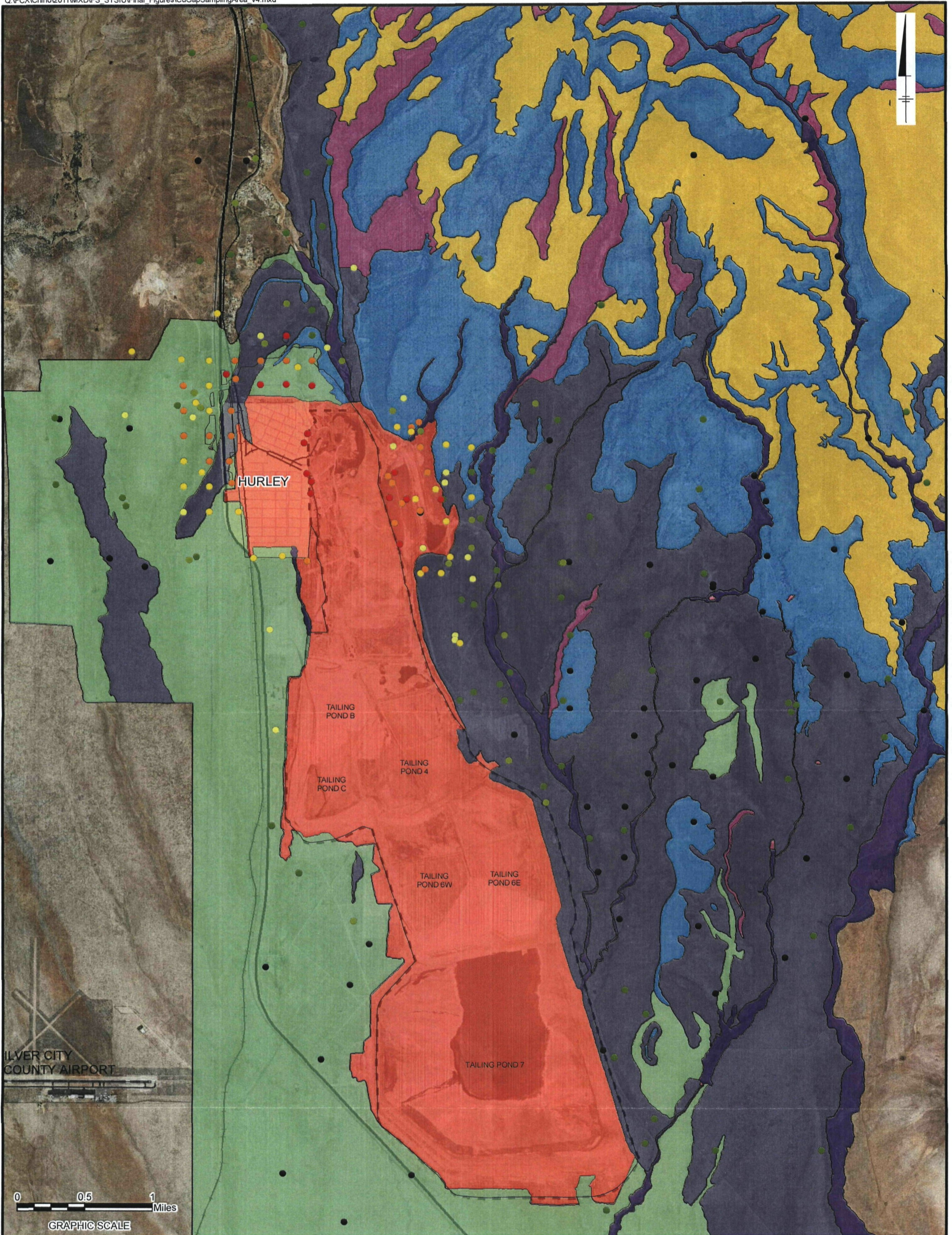
FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

SMELTER/TAILINGS SOILS IU FS PROPOSAL

EXISTING pCu SAMPLE LOCATIONS
AND RANGELAND POLYGONS



FIGURE
1



LEGEND:

Copper Concentration (mg/kg)

- <327
- 327 - 800
- 800 - 1,100
- 1,100 - 1,600
- 1,600 - 2,700
- 2,700 - 5,000
- >5,000

Vegetation

- Fluvial Forest and Shrubland Alliance
- Mesquite/Mixed Grama Shrubland Alliance
- Mine Facilities/Urban
- Ponderosa Pine-Oak Forest Alliance
- Alligator Juniper-Oak Woodland Alliance

- Mountain Mahogany Shrubland Alliance
- Not Classified
- Mixed-Grama Herbacious Alliance
- Alligator Juniper-Oak/Grama Woodland Alliance

Note: Vegetaion alliances will be used as the exposure unit for the SGFB.

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

SMELTER/TAILINGS SOILS IU FS PROPOSAL

EXISTING COPPER SAMPLE LOCATIONS
AND VEGETATION POLYGONS

 **ARCADIS**

FIGURE
2



LEGEND:

- | | | | |
|--------------------------------|----------|--------------------------------------|-----------------------------|
| ● Existing ERA Sample Location | ● 6 - 7 | ▭ pCu < 5 Contour | —+— Railroad |
| ● Proposed Sample Location | ● 7 - 8 | Rangeland Condition OAT Score | — Town Roads |
| pCu | ● 8 - 9 | ▭ NA | — Major Roads |
| ● 3 - 4 | ● 9 - 10 | ▭ 11 - 22 | ▭ Smelter Tailings Boundary |
| ● 4 - 5 | ● >10 | ▭ 23 - 30 | ▭ City Areas |
| ● 5 - 6 | | ▭ 31 - 34 | |

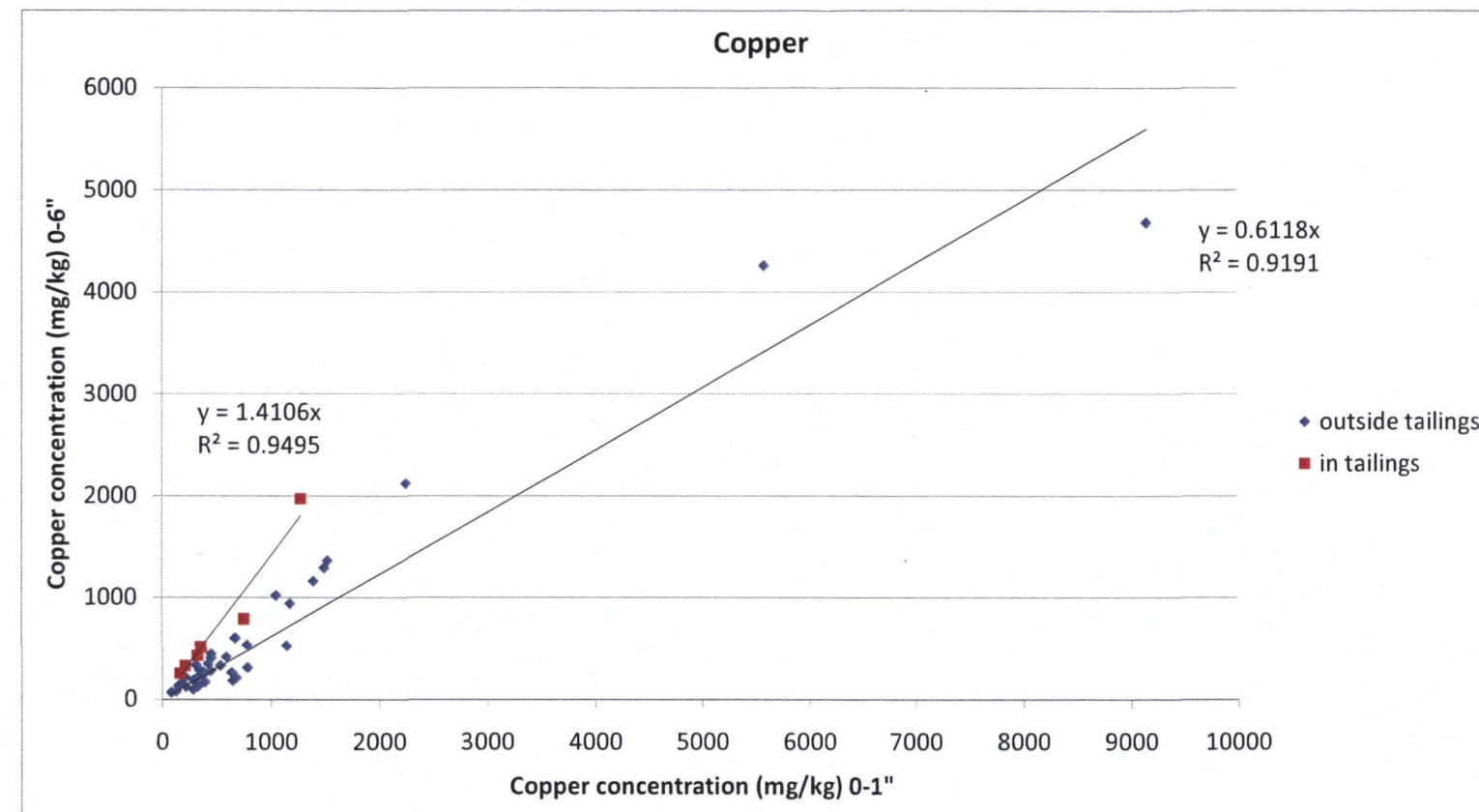
FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

SMELTER/TAILINGS SOILS IU FS PROPOSAL

**OAT SCORE OF RANGELAND POLYGONS
AND PROPOSED RANGELAND CONDITION
SAMPLE LOCATIONS**



FIGURE
3

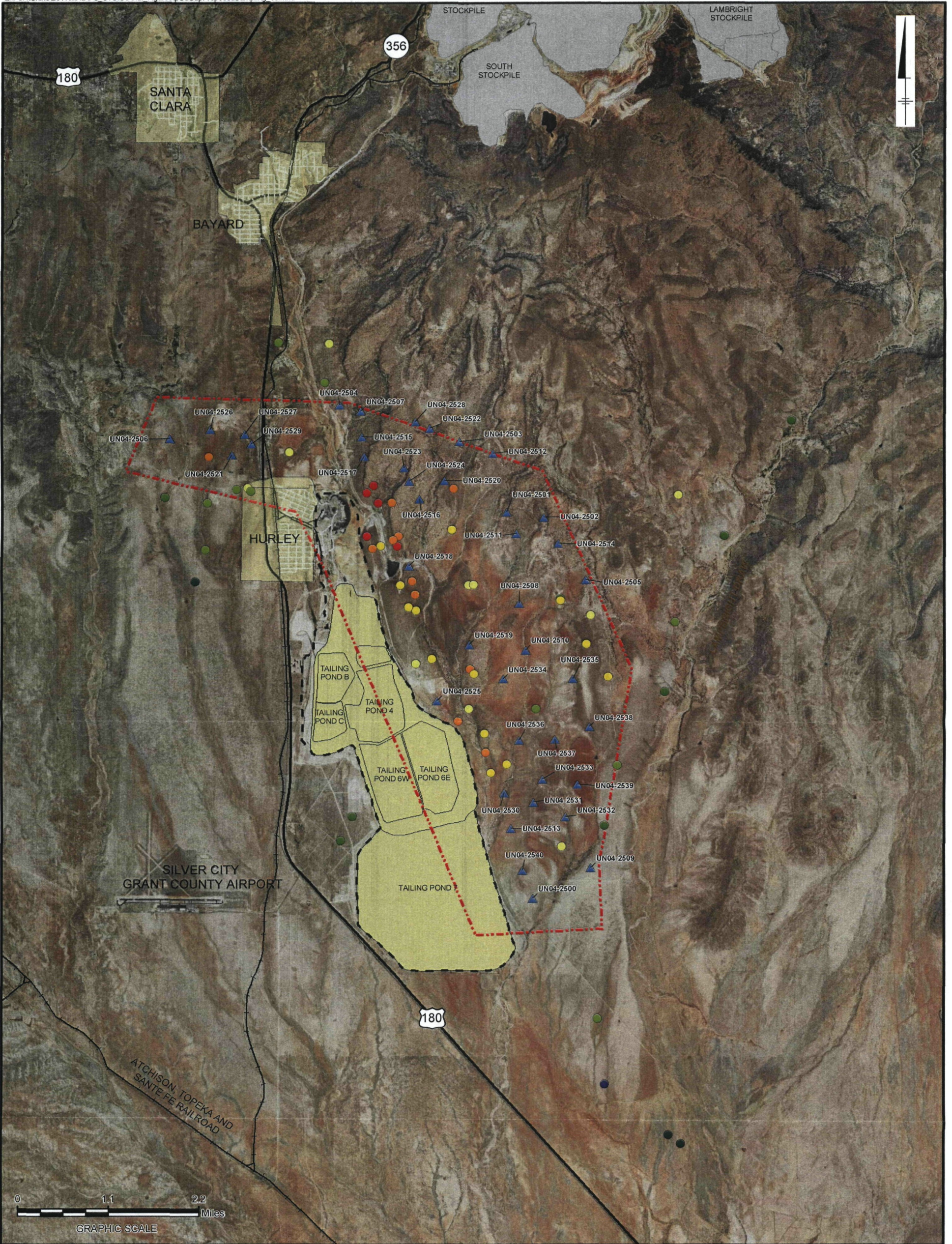


FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO
SMELTER/TAILING SOILS IU FS REPORT

Regression Model for Copper in 0-1 inch
verses Copper in 0-6 inch Samples



FIGURE
4



LEGEND:

- | | | | |
|---------------------------|----------------------------|---------|----------|
| ▲ Sample Location | — Major Roads | pCu | ● 7 - 8 |
| ▭ pCu Area of Uncertainty | ▭ City Areas | ● 3 - 4 | ● 8 - 9 |
| — Railroad | ▭ Stockpiles | ● 4 - 5 | ● 9 - 10 |
| — Town_Roads | ▭ Tailing Ponds | ● 5 - 6 | ● >10 |
| | ▭ Smelter Tailing Boundary | ● 6 - 7 | |

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

SMELTER/TAILINGS SOILS IU FS PROPOSAL

PROPOSED SAMPLING LOCATIONS
FOR pCu GAP CHARACTERIZATION



FIGURE
5



LEGEND:

- | | | |
|---------------------------------------|---------------|-----------------|
| Cu Area of Uncertainty | 800 - 1,100 | City Areas |
| Proposed Woody Cover Sample Locations | 1,100 - 1,600 | Stockpiles |
| Sample Location | 1,600 - 2,700 | TailingPondsAll |
| Lab Confirmation Sample Location | 2,700 - 5,000 | |
| Copper Concentration (mg/kg) | >5,000 | |
| <327 | | |
| 327 - 800 | | |
- 0 1 2 Miles
GRAPHIC SCALE

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

SMELTER/TAILINGS SOILS IU FS PROPOSAL

**PROPOSED SAMPLING LOCATIONS
FOR Cu GAP CHARACTERIZATION**

ARCADIS

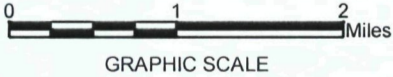
FIGURE 6



LEGEND:

- Percent Slope**

 - <12
 - 12-22
 - 22-32
 - 32-42
 - >42
- City Areas
 - Smelter Tailings Boundary
 - Major Roads
 - Town Roads
 - Railroad



FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

SMELTER/TAILINGS SOILS IU FS PROPOSAL

PERCENT SLOPES

ARCADIS

FIGURE
7



LEGEND

- | | | |
|----------------------------|---|---|
| ▲ Proposed Sample Location | Fluvial Forest and Shrubland Alliance | Mountain Mahogany Shrubland Alliance |
| — Drainage Banks Sampled | Mesquite/Mixed Grama Shrubland Alliance | Not Classified |
| — Drainages | Mine Facilities/Urban | Mixed-Grama Herbaceous Alliance |
| — Town Roads | Pondrosa Pine-Oak Forest Alliance | Alligator Juniper-Oak/Grama Woodland Alliance |
| — Smelter Tailing Boundary | Alligator Juniper-Oak Woodland Alliance | |
| — Major Roads | | |
| — Railroad | | |
- Copper Concentration**
- <327 mg/kg
 - 327 - 800 mg/kg
 - 800 - 1,100 mg/kg
 - 1,100 - 1,600 mg/kg
 - 1,600 - 2,700 mg/kg
 - 2,700 - 5,000 mg/kg
 - >5,000 mg/kg

FREEPORT-MCMORAN CHINO MINES COMPANY
VANADIUM, NEW MEXICO

SMELTER/TAILINGS SOILS IU FS PROPOSAL

PROPOSED WOODY COVER SAMPLE
LOCATIONS ON DRAINAGE BANKS



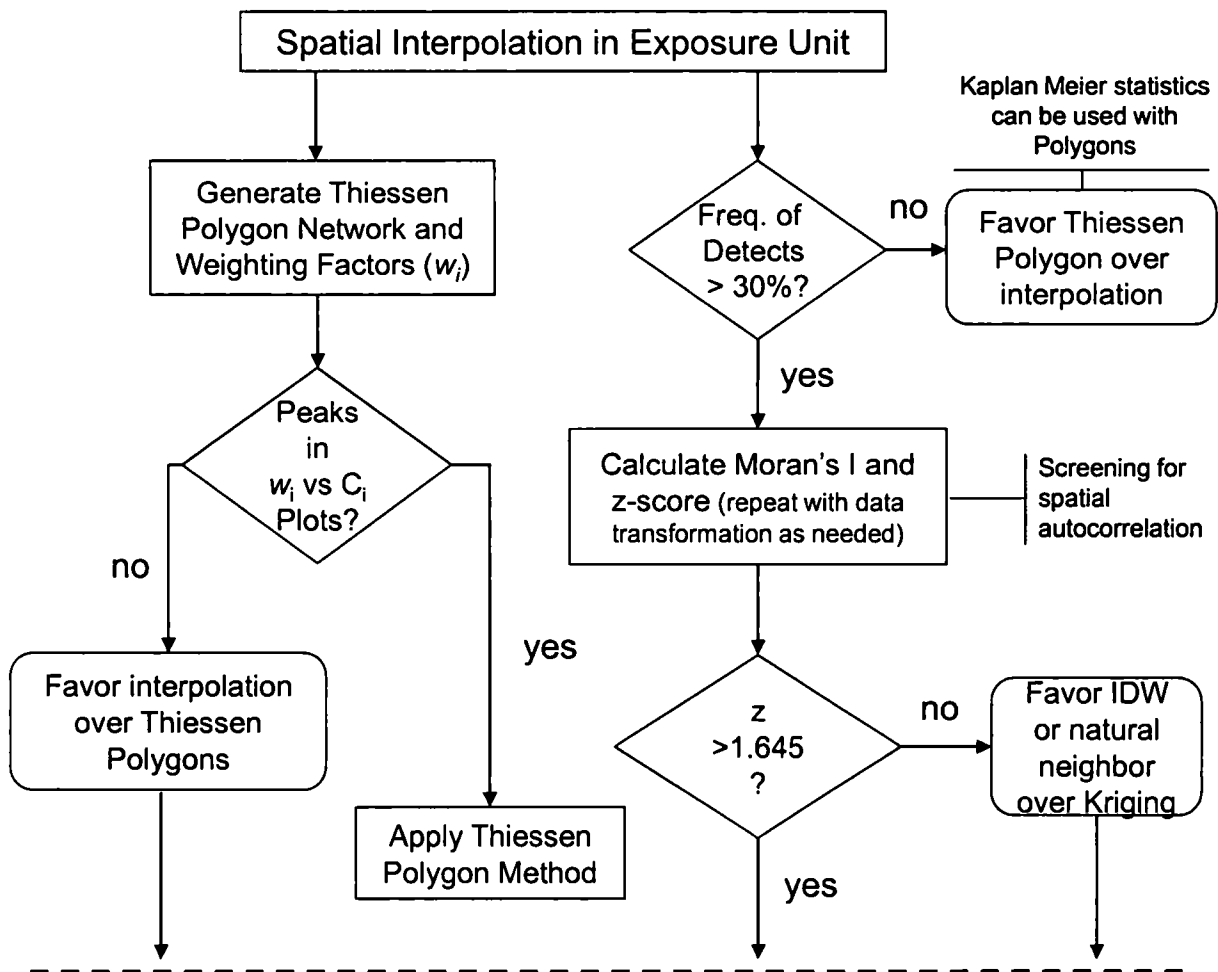
FIGURE
8

FIGURE 9

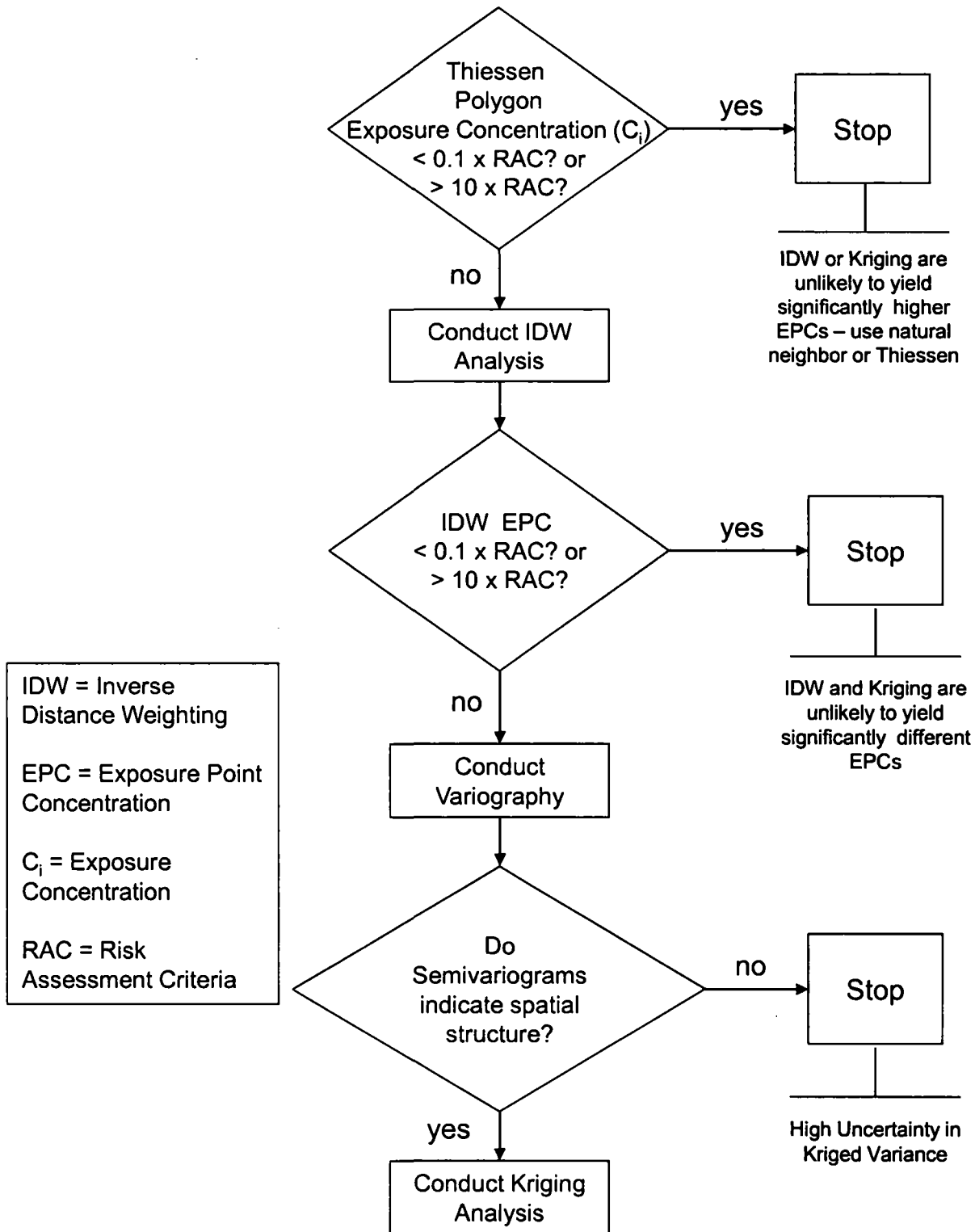
DECISION TREE FOR INTERPOLATION METHOD USED TO DERIVE THE 95 UCL
IN AN EXPOSURE UNIT

Smelter/Tailings Soils IU FS Proposal
Freeport-McMoran Chino Mines Company
Vanadium, New Mexico

Tier 1



Tier 2



APPENDIX B



APPENDIX B – FIELD SAMPLING PLAN: SURFACE WATER RUNOFF QUALITY AND DURATION

B.1 Introduction

This Field Sampling Plan (FSP) has been prepared to guide collection and analysis of surface water runoff samples for the Smelter/Tailing Soils Unit (STSIU) Feasibility Study (FS) Proposal. In accordance with the Administrative Order on Consent (AOC), this FSP is designed to generate data necessary to evaluate the area affected by Pre-FS remedial action criteria (RAC) issued by NMED on March 3, 2011. The purpose of the investigation approach presented in this FSP is to characterize the quality of surface water in STSIU drainage channels during precipitation runoff events and to monitor the depth and duration of flow in the drainage channels during and following precipitation events. Surface water samples have been collected from stock tanks and rainfall pools within the STSIU shortly after precipitation events (Newfields, 2005; Chino, 2008; SRK, 2008); however, surface water samples have not yet been collected during the period of runoff initially generated by precipitation events. This FSP describes the objectives of the proposed investigation, and defines the sampling, analysis, and data gathering methods to be used in the field investigation.

The objectives of data collection efforts described in this Work Plan include:

- Provide additional surface water quality data to support refinement of the surface water conceptual site model and to support the STSIU FS;
- Gain additional insight into the potential variability of surface water quality during precipitation runoff events and to compare surface water quality for several separate runoff events during a single monsoon season;
- Define the duration of flow and presence of water to support classification of drainage channels in the STSIU (i.e., perennial, intermittent, or ephemeral).

The FSP also references the policy, functional activities and quality assurance/quality control (QA/QC) protocols to be used in the investigation, which are specifically stated in the RI Quality Assurance Plan (QAP) (Chino, 1997a). This FSP identifies surface water sampling locations, identifies water depth and duration monitoring locations, defines laboratory analyses for surface water runoff samples, and describes methods for reporting results.

The QAP defines how site-wide QA/QC activities will be implemented during the RI sampling and analysis. The objective of the QAP is to ensure that data are of adequate quality for its intended use. Standard Operating Procedures (SOPs) have been developed as part of the QAP and are incorporated by reference in this FSP.

A site-wide Health and Safety Plan (HASP) (Chino, 1997b, ARCADIS, 2006) has also been developed for the RI field activities. Personnel performing the field tasks outlined in this FSP will review the HASP prior to initiating on-site work. The STSIU sampling activities are to be conducted in accordance with both the QAP and HASP.

B.2 Site Background

The NMED pre-FS RAC for metals in surface waters was based on NMAC §20.6.4, including all the tools and approaches listed in the Code which provide for site specific application. The 2010 – 2011 State of New Mexico Clean Water Act 303(d)/305(b) Integrated Report applies NM WQS to Whitewater Creek. NMAC §20.6.4.803 is titled “Perennial reaches of the Mimbres river downstream of the confluence with Willow Springs canyon and all perennial reaches of tributaries thereto.” Based on an evaluation conducted in 2010, it is clear that the vast majority of these streams should be re-classified as ephemeral. The Statewide Water Quality Management Plan and Continuing Planning Process (WQCC, 2011) provides a decision tree for expedited use-attainability analysis (UAA) Process for unclassified ephemeral streams (see Figure II-2 in WQCC, 2011). Chino is developing hydrology work plan to provide determination of hydrologic regime for tributary channels within the STSIU sub-watersheds. The objectives of the hydrology work plan include (1) conduct expedited UAA for STSIU drainages based on application of New Mexico’s Hydrology Protocol and (2) conduct formal UAA for stock tanks within STSIU. This work plan will be submitted to the Surface Water Quality Bureau on a parallel track to this STSIU FS Proposal.

For most metals, criteria are expressed as a function of site-specific water hardness; however, these hardness-adjusted criteria do not account for other key chemical parameters that potentially alter metal bioavailability and toxicity. As such, other options are available to derive site-specific water quality criteria. Section 131.11 (b) (ii) of the federal water quality standards regulation (40 CFR Part 131) provides the regulatory mechanism for a State to develop site-specific criteria for use in water quality standards. Further, as a result of New Mexico’s Triennial Review of surface water standards, mechanisms are available for establishing segment-specific surface water criteria. As specified in Section 20.6.4.10 part D of New Mexico’s Standards, site-specific criteria may be developed when physical or chemical characteristics at a site alter the bioavailability or toxicity of a chemical. Site specific criteria may be derived from one of the following procedures: water effect ratio (WER), biotic ligand model (BLM), recalculation procedure, or the resident species procedure.

Based on these regulations and a preliminary review of Chino’s surface water chemistry, WER and/or BLM procedures are appropriate for deriving site-specific metal criteria for surface waters at

Chino. The criteria-adjustment work plan will also be submitted to the Surface Water Quality Bureau concurrent with this STSIU FS Proposal and findings may result in a rulemaking petition. The work plan will describe studies that will be used to understand the site-specific toxicity of copper in STSIU surface waters. These studies are based on scientifically-defensible methods described in NMAC §20.6.4.10, and are designed to incorporate the effects of site-specific water chemistries on the bioavailability and toxicity of copper to aquatic organisms. It is further envisioned that results from these criteria-adjustment studies will provide the data necessary for the establishment of site-specific copper criteria.

In addition to these studies, this appendix provides a separate work plan for further understanding the conceptual site model of STSIU drainages and stock tanks. Previous surface water sampling conducted in STSIU drainages has indicated that Pre-FS RAC have been exceeded for select constituents including, primarily, copper (Chino, 2008; SRK, 2008). These samples were collected from rainfall pools and stock tanks and may not be representative of surface water quality in STSIU drainages during precipitation runoff events. This work plan includes the use of storm water samplers that sample runoff, and the data will be used to allocate metals load in surface water to upgradient sources, soil sources or legacy sediment sources.

B.3 Data Quality Objectives

This section describes the Data Quality Objectives (DQO) process used to address the potential impacts to surface water from leaching of soil and sediments in STSIU drainages. The primary objective of this pathway is to assess whether leaching of sediment or soil effects surface water quality. The primary objective is supported by the following decision and criteria:

Decision: Are constituent concentrations in STSIU surface water runoff greater than decision criteria?

Criteria: Final Surface Water Quality Standards based upon work conducted in accordance with §20.6.4 NMAC.

Data needed for this decision include constituent concentrations in drainage surface water runoff including data from the *Groundwater Quality Pre-Feasibility Study Remedial Action Criteria for Drainage Sediments* (ARCADIS 2011).

Following receipt of analytical data for surface water runoff, constituent concentrations in each sample will be compared to decision criteria. A direct numerical comparison of surface water runoff constituent concentration to decision criteria will be performed for each location. If constituent concentrations in surface water runoff are less than decision criteria, then surface water

runoff will not require additional evaluation. In addition, all data will be used to allocate metals load in surface water to upgradient sources, soil sources or legacy sediment sources. The results of the investigation and evaluation will be documented for potential use in assessing surface water quality Pre-FS RAC for STSIU drainages and understanding potential remedial alternatives.

The following sections present a study designed to evaluate surface water quality during precipitation runoff events and to measure the depth and/or duration of flow at select locations within STSIU drainages.

B.4 Sample Collection and Laboratory Analysis

The surface water runoff quality and duration sampling program is intended to address the following specific sampling objectives:

- assess quality of surface water in STSIU drainages during precipitation runoff events at select locations within the STSIU with the greatest potential for exceeding Pre-FS RAC for surface water quality based on all historical surface water metals concentrations collected in the STSIU. Locations with the highest historic metals concentrations were selected for sampling;
- measure the depth and duration of flow in STSIU drainages during precipitation runoff events at select locations within the STSIU with the greatest potential for exceeding Pre-FS RAC for surface water quality; and
- measure the duration of flow in drainage channels at additional STSIU locations with lower potential for exceeding Pre-FS RAC for surface water quality.

Collection of surface water samples and data quality assessment will follow Standard Operating Procedures (SOPs) included as part the AOC Quality Assurance Plan (QAP) (SRK, 1997) adopted by Chino. This section provides specific details for the proposed sampling.

Surface water runoff samples will be collected from a total of eight proposed drainage channel locations within the STISU boundary (Figure 1). Drainage channels upgradient of stock ponds and other drainage locations with previous elevated detections of copper are targeted for proposed surface water sampling locations. Surface water samplers will be installed at two to three different heights at each location, depending upon channel geometry, to collect samples from different portions of the precipitation runoff hydrograph. Surface water samples will be collected during three separate precipitation events at each location for a total of 24 samples (maximum), plus two

field duplicate samples, and one MS/MSD sample per sampling event. Two surface water samplers will be placed at each of the two or three heights. One sampler will collect water for analysis of inorganic constituents. The other sampler will collect water for analysis of organic carbon content. Surface water sample locations are listed in Table 1.

The initial surface water sampler installation will involve setting up surface water sampler mounting kits at the eight proposed surface water sampling locations. One mounting kit will be installed for each sampler. Each mounting kit contains a reusable mounting tube that will be secured to a post in the water channel. Once the mounting kits are in place, the surface water samplers are inserted in the mounting tubes prior to each sampling event. Surface water samplers are sent directly to the lab for processing. There is no need to transfer the sample to another sample container.

Three sampling events will occur over the duration of the monsoon season (July through September 2011). Following a significant rain event, surface water samplers will be retrieved from each sample location 24 to 48 hours after the precipitation has stopped based on road conditions and accessibility. The sample will then be shipped on ice to ACZ Laboratory, Inc. (ACZ) in Steamboat Springs, CO for analysis following appropriate chain of custody SOPs provided in the AOC QAP (SRK, 1997). All sample preservation (other than shipment of samples on ice) and filtration will be conducted at the lab. Surface water samples will be analyzed for analytes listed in Table B-2.

Table B-2. Surface Water Analyses

| Analyte | Method |
|---------------------------------|-------------------------|
| <i>Inorganic Constituents</i> | |
| Aluminum, Total and Dissolved | M200.8 ICP-MS |
| Cadmium, Total and Dissolved | M200.8 ICP-MS |
| Calcium, Total and Dissolved | M200.7 ICP |
| Copper, Total and Dissolved | M200.8 ICP-MS |
| Lead, Total and Dissolved | M200.8 ICP-MS |
| Magnesium, Total and Dissolved | M200.7 ICP |
| Zinc, Total and Dissolved | M200.8 ICP-MS |
| Sulfate | D516-02 - Turbidimetric |
| Alkalinity as CaCO ₃ | SM2320B - Titration |
| <i>Organic Constituents</i> | |

| | |
|---------------------------------|---------|
| Carbon, Dissolved Organic (DOC) | SM5310B |
|---------------------------------|---------|

The eight proposed surface water runoff sampling locations will also be monitored for water level and water duration monitoring based on temperature measurements. An additional 13 locations have been proposed for water duration monitoring only. These 13 water duration monitoring locations have previously been sampled for surface water quality. The purpose of water level monitoring is to record the presence and depth of surface water runoff at the targeted locations. Monitoring of temperature will indicate the duration that water is flowing in the drainage channels and aid in determining if the surface water drainages exhibit perennial, intermittent, or ephemeral characteristics at each location. The selected eight surface water runoff and 13 water duration monitoring locations display a variety of channel characteristics.

Water duration monitoring will be accomplished by recording temperature at the base of the drainage channels at each of the monitoring locations at periodic intervals (e.g., 15-minute or 30-minute intervals) over the course of several months. Temperature data will be used to assess presence of water based on the measured diurnal variance in temperature. When water is not present, the diurnal temperature variance is essentially equivalent to changes in air temperature throughout the day. When water is present, the diurnal temperature variance is considerably damped relative to the diurnal variance in air temperature. The difference between air temperature and water temperature variance is then used to assess presence/absence of water.

A combination pressure and temperature transducer will be placed at each of the eight surface water runoff sampling locations to measure surface water runoff depth and temperature. The other 13 locations will receive data loggers that record temperature only. All transducers and data loggers will be placed in the bottom of the drainage channels and secured in place to record data throughout the monsoon season. Pressure and temperature recordings will be downloaded at the end of the monsoon season.

B.5 Data Evaluation

A data quality assessment will be performed to determine if the data are of sufficient quality and quantity to meet the project objectives and are sufficiently representative of the medium under evaluation for the specified end use. This will be followed by an analysis of the chemical results to determine if the constituent concentrations in S/TSIU surface water runoff are greater than the DQO decision criteria.

B.5.1 Data Quality Assessment

All data will be validated in accordance with National Functional Guidelines for Inorganic Review (EPA, 1994). The data validation will meet the minimum requirements specified in EPA's Guidance for Data Usability in Risk Assessment (DURA) (EPA, 1992). Quantitative data quality assurance parameters used to assess the data quality include: reporting limits, accuracy, precision, and completeness. In addition, the data will be evaluated against the qualitative data quality assurance parameters, including representativeness and comparability. The data will be evaluated against these parameters in order to determine the usability of the data for making decisions.

B.5.2 Data Analysis

The data analysis approach follows the DQOs decision statement and decision criteria. Analytical data from the surface water runoff samples will be reviewed to allocate metals load in surface water between upgradient sources and to determine if concentrations exceed the decision criteria consisting of the Pre-FS RAC for surface water.

The loading of metals in surface water will be evaluated using the water depth data derived from the pressure transducers along with channel geometry and channel roughness. These three parameters will be used to estimate total volumetric flow of water for each storm event for which water samples are collected. The estimated flow from above and the water chemistry data will be used to calculate metals loading for the area of the basin located above each storm water sampling location. Existing soil and sediment concentration data will be evaluated to assess relative potential loading contributions to surface water from soil versus from sediments. In addition, surface water concentration data for storm water samples will be compared with surface water samples previously collected between storm events. Using the soil, sediment, and surface water concentrations Chino will determine the metals loading to surface water from these three sources.

If measured surface water runoff concentrations do not exceed the decision criteria then no further work is necessary. If measured surface water runoff concentrations exceed decision criteria, then an assessment of potential surface water runoff quality remedies will be carried forward to the FS.

B.7 Schedule

Installation of the surface water runoff sampler mounting kits, pressure and temperature transducers, and temperature data loggers, scheduled for June 2011, will take approximately one week. Sample collection and surface water sampler replacements will be performed shortly after

cessation of precipitation events (assuming safe access) and will take approximately one day per precipitation event with three sampling events scheduled for the monsoon season, July through September 2011. Data validation will commence upon receipt of the final laboratory analytical data report and is expected to require 6 weeks for completion. End of the monsoon season data collection, scheduled for November 2011, will take approximately one week.

Preparation of an appendix for the STSIU FS Report will occur after completion of the end of monsoon season data collection effort scheduled for November 2011. The appendix will include descriptions of field equipment installation and surface water sample and data collection events, data tables with analytical data results with comparison of surface water quality data to Pre-FS RAC for surface water, graphs of water levels with time for each of the eight water depth monitoring locations, and a table with duration of water for all surface water monitoring locations. The report will also include an assessment of data quality and data usability including a copy of the data validation report as an attachment.

B.8 References

ARCADIS US, Inc. 2006. *Interim Removal Action for Smelter/ Tailing Soils Investigation Unit, Health and Safety Plan*. Prepared for Chino Mines Company, Hurley, New Mexico

ARCADIS US, Inc. 2011. *Groundwater Quality Pre-Feasibility Study Remedial Action Criteria for Drainage Sediments*. Prepared for Chino Mines Company, Hurley, New Mexico. April

Chino, 1995, Administrative Order on Consent, Investigation Area, Remedial Investigation Background Report, Chino Mines Investigation Area. October.

Chino, 1997a. Administrative Order on Consent, Quality Assurance Plan, Chino Mine Investigation Area. March.

Chino, 1997b. Administrative Order on Consent, Health and Safety Plan, Chino Mine Investigation Area. March.

Chino, 2008. Technical Memorandum Surface Water Sampling & Analysis of Rainfall Pools, Addendum to Administrative Order on Consent Revised Remedial Investigation Report for the Smelter/Tailing Soils Investigation Unit. June.

NewFields, 2005. Chino Mines Administrative Order on Consent, Site-Wide Ecological Risk Assessment. February.

SRK. 2008. Administrative Order on Consent Remedial Investigation Report for the Smelter/Tailing Soils Investigation Unit, Revision 3. May.

Table 1
Surface Water Runoff Sampling and Temperature
Monitoring Locations

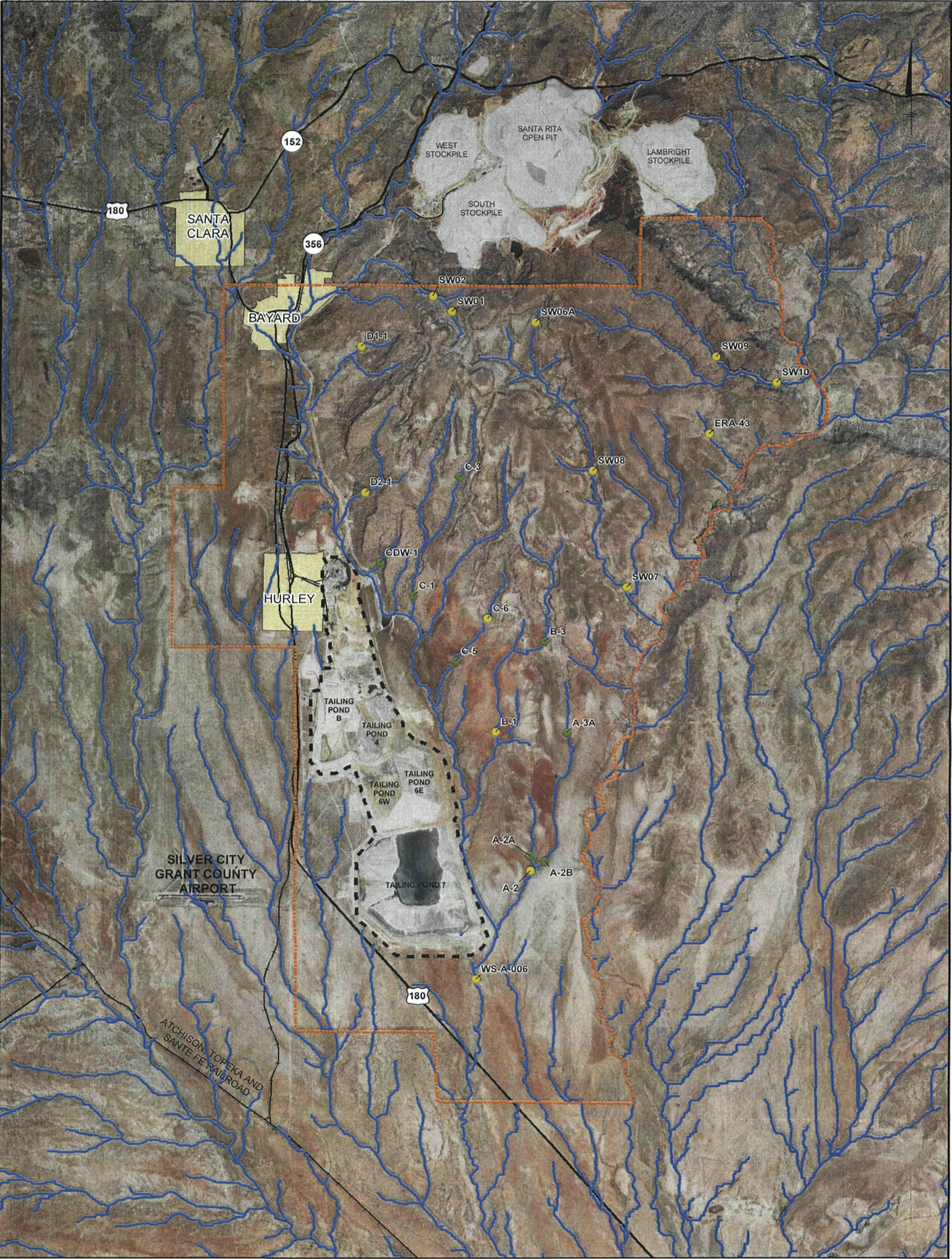
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SMELTER/TAILING SOILS IU FEASIBILITY STUDY PROPOSAL

| Surface Water Runoff Sampling Locations ¹ |
|--|
| A-2A A-2B A-4A B-3 C-1 C-3 C-5 CDW-1 |
| Temperature Monitoring Locations ² |
| WS-A-006 A-2 B-1 C-6 D-1-1 D-2-1 SW01 SW02 SW06A SW07 SW08 SW09 SW10 |

Notes:

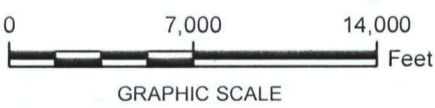
¹ - Surface water runoff sampling locations include surface water sampling, water depth, and water duration monitoring

² - Temperature monitoring locations include temperature monitoring only



LEGEND

- Temperature Monitoring Location
- Stormwater Sampling Temperature and Pressure Monitoring Location
- STSIU Boundary
- Smelter Tailing boundary
- Highway
- Railroad
- Stockpiles
- Local Cities



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SMELTER/TAILINGS SOILS IU FS PROPOSAL

STORM WATER AND TEMPERATURE
MONITORING LOCATIONS



FIGURE
1